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THE MATLOCK FORAY.

May 16th to 20th, 1924.

By E. M. Wakefield, M.A., F.L.S.

THE party which assembled at the Chatsworth Hydro on the evening of May 16th was not a large one, but numbers were reinforced next day by various members and visitors who were staying elsewhere.

On Saturday morning a full charabanc load started at 10 o'clock for Dovedale.

The valley was entered at Alsop-en-le-Dale, and worked as far as Thorpe, which was reached in time for tea. The scenery of Dovedale was much enjoyed, but the locality proved not very productive of fungi. At the outset abundant material of *Uromyces Ficariae* and the aecidial stage of *Uromyces Poae* was found on *Ranunculus Ficaria* growing on damp ground near the stream. In the same spot some fallen willows yielded fine specimens of *Ocellaria aurea*. The day's finds consisted for the most part of such microfungi—the larger forms being very few and far between. *Mitrophora hybrida* and *Disciotis venosa* were the most interesting of the larger fungi found.

After dinner in the evening Professor Kawagoe, a visitor, gave a most interesting talk on some Japanese fungi. In the first place he dealt in detail with the edible species, especially Shiitake (*Cortinellus Shiitake*) and Matsudake (*Cortinellus edodes*), describing their characteristics and the method of cultivation. He pointed out that Matsudake always grows in association with *Pinus densiflora* (or rarely *Tsuga japonica*), whereas Shiitake is characteristic of woods composed of Fagaceae (*Quercus, Fagus, Castanea*, etc.). The latter species is dried, and is in fact better dried than fresh. In the dried state it is exported to China.

Following this Professor Kawagoe added some notes as to some of the more important injurious fungi, notably those parasitic on the rice plant. At the close, after some interesting discussion, a hearty vote of thanks was accorded to Professor Kawagoe.

On Sunday the excursion chosen by all members present was to the Via Gellia, near Cromford. Here were very steep woods on either side of the road for a mile or two, and some hours were spent exploring these. As might have been expected, the slopes yielded little, and members soon found that it was more profitable to keep to lower ground close to the stream. Here *Urocystis Anemones* and *Plasmopara pygmaea* were found on

Anemone nemorosa, and *Peronospora Schleideni* on garlic. On some submerged twigs, etc., Mr R. W. Marsh found *Apostemidium Guernisaci*.

In the evening a short business meeting was held, instead of on the Monday, owing to the fact that many of the party were leaving the following day.

For the 1925 Spring Foray Tintern was proposed by Mr Rea and seconded by Dr W. Elliott. The date was to be arranged if possible in the Easter vacation.

Two new members were elected, and the meeting closed with hearty votes of thanks to Mr R. W. Butcher, who had made the arrangements for the various excursions, and to the landowners who had permitted their ground to be worked. Mr Cheesman then gave a talk on Polyporaceae, illustrated by numerous specimens.

The excursion on the Monday was to Alderwasley, lying between Whatstandwell and Ambergate. The party divided into two, one section going on to Ambergate at once, while the other alighted at Whatstandwell and worked back through the woods to Ambergate, where both sections united for tea. This ground appeared the most promising yet seen, but the day was marred by rain, which towards tea-time became very heavy and made most people hurry for shelter.

Several interesting Agarics were found on this day, such as *Entoloma clypeatum*, *Psilocybe bullacea* and *Pleurotus septicus*. Some very fine specimens of *Mitrophora hybrida* were secured, and a fir wood yielded abundant material of *Marasmius* (= *Collybia*) *esculentus*, as well as various microfungi on the fallen cones.

A complete list of the fungi gathered is appended, for assistance in compiling which the Secretary is indebted to all the members present, and especially to Mr Ramsbottom, Mr Rea and Mr Buddin.

Complete List of Species gathered during the Foray.

D. = Dovedale; *G.* = Via Gellia; *A.* = Alderwasley.

BASIDIOMYCETES.

Armillaria mellea (Vahl.) Fr., *D.*, *G.* (*rhizomorphs only*).
Mycena ammoniaca Fr., *D.*
Marasmius esculentus (Wulf.) Karst., *A.*
Pleurotus septicus Fr., *A.*
Pluteus cervinus (Schaeff.) Fr., *G.*, *A.*
Entoloma clypeatum (Linn.) Fr., *A.*
Pholiota mutabilis (Schaeff.) Fr., *D.*, *G.*, *A.*, marginata (Batsch) Fr., *D.*, *A.*, togularis (Bull.) Fr., *A.*
Galera tenera (Schaeff.) Fr., *D.*, hypnorum (Schrank) Fr., *D.*, *G.*, *A.*
Stropharia semiglobata (Batsch) Fr., *A.*
Hypholoma fasciculare (Huds.) Fr., *G.*, *A.*, sublateritium (Schaeff.) Fr., *A.*, appendiculatum (Bull.) Fr., *D.*

Panaeolus sphinctrinus Fr., *A.*
Psilocybe bullacea (Bull.) Fr., *A.*, foenisecii (Pers.) Fr., *G.*
Polyporus squamosus (Huds.) Fr., *Matlock*, adustus (Willd.) Fr., *D.*, *A.*, betulinus (Bull.) Fr., *A.*
Fomes ferruginosus (Schrad.) Massee, *D.*, annosus Fr., *A.*
Polystictus versicolor (Linn.) Fr., *G.*, *A.*
Poria hymenocystis B. & Br., *A.*
Daedalea quercina (Linn.) Fr., *A.*
Irpex obliquus (Schrad.) Fr., *D.*, *A.*
Odontia farinacea (Pers.) Bres., *A.*
Stereum spadiceum Fr., *A.*, rugosum (Pers.) Fr., *D.*, *G.*, *A.*, sanguinolentum (A. & S.) Fr., *A.*, hirsutum (Willd.) Fr., *A.*
Hymenochaete tabacina (Sow.) Lév., *A.*, corrugata (Fr.) Lév., *D.*, *G.*
Corticium laeve (Pers.) Fr., *G.*, Sambuci (Pers.) Fr., *D.*, subcoronatum v. H. & Litsch., *A.*, confluens Fr., *A.*, porosum B. & C., *G.*, *A.*
Peniophora cremea Bres., *D.*, *A.*, hydnoides C. & M., *D.*, incarnata (Pers.) Cke., *G.*, cinerea (Fr.) Cke., *D.*, *G.*
Coniophora puteana (Schum.) Karst., *G.*
Solenia anomala (Pers.) Fr., *A.*
Tremella frondosa Fr., *G.*
Exidia glandulosa (Bull.) Fr., *D.*
Dacryomyces deliquescens (Bull.) Duby, *D.*, *A.*
Sphaerobolus stellatus (Tode) Pers., *A.*

UREDINEAE.

Uromyces Ficariae (Schum.) Lév., *D.*, *G.*, *A.*, Alchemillae (Pers.) Lév., *D.*, Valerianae (Schum.) Fuck., *D.*, Poae Rabenh., *D.*, *G.* (*Aecidium*).
Puccinia fusca (Relh.) Wint., *G.*, Violae (Schum.) DC., *D.*, Saxifragae Schlecht., *D.*, Adoxae Hedw. fil., *D.*, *G.*, Chondrillae Corda, *D.*, Lapsanae (Schultz) Fuck., *D.*, Menthae Pers., *D.*, Magnusiana Koern., *A.*, Poarum Niels., *A.*
Phragmidium Fragariastri (DC.) Schroet., *D.*, Sanguisorbae (DC.) Schroet., *D.*, subcorticium (Schrank) Wint., *D.*
Melampsora Rostrupii Wagn., *D.* (*Aecidium*).

USTILAGINEAE.

Ustilago violacea (Pers.) Wint., *D.*, *G.*, *A.*
Urocystis Anemones (Pers.) Wint., *D.*, *G.*, Violae (Sow.) Schroet., *D.*

PYRENOMYCETES.

Nectria cinnabarina (Tode) Fr., *G.*, *A.*, galligena Bres., *A.*
Ceratostomella pilifera Wint., *A.*
Rosellinia aquila (Fr.) de Not., *D.*
Melanomma pulvis-pyrius (Pers.) Fuck., *A.*
Stigmatea Robertiani Fr., *D.*
Leptosphaeria acuta (Moug. & Nestl.) Karst., *D.*, *G.*, *A.*
Melanconis stilbostoma (Fr.) Tul., *D.*, *G.*, *A.*
Eutypa Acharii Tul., *G.*, flavo-virens Tul., *D.*
Diatrype Stigma (Hoffm.) de Not., *D.*
Diatrypella quercina (Pers.) Nke., *D.*
Cryptosphaeria eunomia (Fr.) Fuck., *D.*, *G.*
Diaporthe salicella (Fr.) Sacc., *G.*
Xylaria Hypoxylon (Linn.) Grev., *D.*, *G.*
Hypoxylon multiforme Fr., *A.*
Phyllachora graminis (Pers.) Fuck., *D.*
Endodothella Junci (Fr.) Theiss. & Syd., *A.*
Dichaena quercina (Pers.) Fr., *A.*
Rhopographus Pteridis (Sow.) Wint., *A.*
Aulographum vagum Desm., *A.*

DISCOMYCETES.

Mitrophora hybrida (Sow.) Boud., *D.*, *G.*, *A.*
Disciotis venosa (Pers.) Boud., *D.*, *G.*

Cheilymenia stercorea (Pers.) Boud., *D.*
Coprobia granulata (Bull.) Boud., *D.*
Apostemidium Guernisaci (Cr.) Boud., *G.*
Polydesmia pruinosa (B. & Br.) Boud., *A.*
Calloria fusarioides (Berk.) Fr., *D.*
Orbilia xanthostigma Fr., *A.*
Chlorosplenium aeruginosum (Oeder.) de Not., *G.* (*mycelium only*).
Helotium herbarum (Pers.) Fr., *G.*, *A.*, cyathoideum (Bull.) Karst., *D.*
Dasyscypha virginea (Batsch) Fuck., *D.*, *A.*
Trichoscypha calycina (Schum.) Boud., *D.*, *G.*, *A.*
Hyaloscypha hyalina (Pers.) Boud., *G.*, *A.*
Micropodia aspidiicola (B. & Br.) Boud., *A.*
Mollisia cinerea (Batsch) Karst., *D.*, *G.*, *A.*, atrata (Pers.) Karst., *A.*, lignicola Phill., *A.*, fusca (Schum.) Karst., *D.*
Ocellaria aurea Tul., *D.*
Phacidium multivalve (DC.) Kunze & Schum., *A.*
Rhytisma acerinum (Pers.) Fr., *G.*

PHYCOMYCETES.

Plasmopara nivea (Ung.) Schroet., *G.*, pygmaea (Ung.) Schroet., *G.*, *A.*
Peronospora parasitica (Pers.) Tul., *D.*, Schleideni Unger, *G.*

FUNGI IMPERFECTI.

Phoma Urticae Schulz. & Sacc., *A.*
Macrophoma Fraxini Delacr., *G.*
Phomopsis Corni (Fuck.) Trav., *D*, scobina von Höhn., *G.*
Dilophospora graminis Desm. on *Holcus*, *A.*
Septoria Rubi West., *A.*
Monilia aurea Gmel., *D.*, *G.*
Ovularia obliqua (Cooke) Oud., *D.*
Botrytis cinerea Pers., *G.*, *A.*
Penicillium expansum Link, *A.*
Rhinotrichum Thwaitesii B. & Br., *D.*
Tilachlidium tomentosum (Schrad.) Lind., *D.*, *G.*

LICHENS OF THE MATLOCK FORAY.

By H. H. Knight, M.A.

THE trees everywhere in this district were remarkably bare, the only corticolous lichens noticed being three common species of *Parmelia* and *Lecanora varia*. In Dovedale, with its exposed limestone rocks, lichens were plentiful, and here *Solorina saccata* in particular attracted notice. A species of *Arthopyrenia* growing on stones by the River Dove with *Verrucaria margacea* was named *A. arenicola* by Mr Paulson. All the lichens in this list were found on the Derbyshire side of the Dove. The rocks in the woods by the Via Gellia were too much sheltered by trees for lichens to be plentiful. The woods at Alderwasley were on Millstone Grit, and with the exception of the genus *Cladonia* were poor in lichens. Millers Dale was also visited; here the lichens were similar to those of Dovedale.

D. = Dovedale; *G.* = Via Gellia; *A.* = Alderwasley; *M.* = Millers Dale.

Chaenotheca melanophaea Zwackh, *G.*
Placynthium nigrum S.F.Gray, *D.*
Collema granuliferum Nyl., *D.*
C. furvum Ach., *D.*
Leptogium Schraderi Nyl., *D.*
L. lacerum Gray var. pulvinatum Koerb., *D.*
Peltigera canina Willd., *D.*
P. rufescens Hoffm., *A.*, var. praetextata Nyl., *A.*
P. polydactyla Hoffm., *D.*
Solorina saccata Ach., *D.*, *M.*
Parmelia physodes Ach., *D.*, *A.*
P. saxatilis Ach., *A.*
P. sulcata Tayl., *D.*
P. fuliginosa Nyl. var. laetevirens Nyl., *D.*
Cetraria glauca Ach., *A.*
C. aculeata Fr., *A.*
Xanthoria parietina Th.Fr., *D.*, *G.*, *A.*, *M.*
Placodium callopismum Mér., *D.*, *M.*
P. murorum DC., *D.*, *M.*
P. aurantiacum Anzi var. flavovirescens Hepp., *D.*
P. pyraceum Anzi, *D.*, *M.*
P. variabile Nyl., *D.*, *M.*
P. ochraceum Anzi, *M.*
P. rupestre Branth. & Rostr., *D.*, *G.*, *M.*
Candelariella vitellina Müll.-Arg., *A.*
Physcia caesia Nyl., *G.*, *A.*
Rinodina Bischoffii Koerb., *M.*
Lecanora muralis Schaer., *A.*
L. galactina Ach., *M.*
L. varia Ach., *D.*, *A.*
L. calcarea Sommerf., *D.*, *M.*
Lecania candicans A. Zahlbr., *D.*
Cladonia sylvatica Hoffm., *A.*
C. pyxidata Hoffm., *D.*, *A.*
C. fimbriata Fr., *A.*
C. rangiformis Hoffm., *D.*
C. squamosa Hoffm., *A.*
C. flabelliformis Wain., *A.*
Gyalecta cupularis Schaer., *G.*, *M.*
Lecidea lurida Ach., *D.*, *M.*
L. uliginosa Ach., *A.*
L. immersa Ach., *D.*, *M.*
L. ochracea Wedd., *D.*
Biatorina coeruleonigricans A.L.Sm., *D.*, *M.*
B. lenticularis Koerb., *D.*
Bilimbia aromatica Jatta, *D.*
B. sabuletorum Branth. & Rostr., *D.*
Opegrapha calcarea Turn., *D.*, *G.*
Dermatocarpon miniatum Th.Fr., *D.*
D. lachneum A.L.Sm., *M.*
Verrucaria margacea Wahlenb., *D.*
V. nigrescens Pers., *D.*, *M.*
V. glaucina Ach., *D.*
V. Dufourii DC., *D.*, *M.*
V. muralis Ach., *D.*
V. rupestris Schrad., *D.*, *M.*
V. integra Carroll, *D.*
V. calciseda DC., *D.*, *M.*
Thelidium immersum Mudd, *D.*
T. incavatum Mudd, *D.*
Polyblastia Schraderi A.L.Sm., *D.*
Acrocordia epipolaea A.L.Sm., *D.*, *M.*
Arthopyrenia arenicola A.L.Sm., *D.*
Porina chlorotica Wain., *D.*

RECENT WORKS ON LICHENS.

By A. Lorrain Smith, F.L.S.

THERE is no halting place in the study of Lichenology any more than in other branches of science, and though only a short time has elapsed since the previous record of work was compiled*, there has been a considerable accumulation of interesting material. Some papers that were then unavoidably omitted have been dealt with in the present survey and as in recent months the publication and exchange of papers has reached almost the freedom of pre-war years, it is hoped that on this occasion there are no serious lacunae.

The arrangement of subjects follows in the main on previous

* Trans. Brit. Mycol. Soc. VIII, pp. 193–200 (1923).

lines, but works on systematy have received more attention in view of the great importance of some of the publications, and because of the notes on general questions included with the descriptions of genera or species.

The Lichen Thallus.

Symbiosis or Parasitism. Tobler (1920, 1) has reviewed the theories of Schwendener and Elfving as to the relations between the symbionts in the lichen thallus and he also records his own observations. He found instances of perishing gonidia in the grip of the hyphae—instances in which the hyphae had the advantage and the gonidia tended to die off; but he also records cases where, owing to some conditions of habitat on growth, the gonidia increased enormously and the fungus succumbed. This would normally occur where there was excessive moisture or absence of light, etc. He concludes that in the lichen thallus there is constant balance of conditions between the two symbionts: the perfect balance he terms the optimum.

He discusses also the relation between alien fungi and the thallus of the lichens on which they frequently grow. He rejects the view that regards all these as purely parasitic fungi and prefers to look on them as "parasymbionts" living more or less in symbiotic union with the lichen gonidia.

Bachmann (1923, 3) has given a further contribution to this subject. He affirms the present almost universal acceptance of the theory of symbiosis, though some students still talk and write of *slavery*, *helotism*, or even *endosaprophytism* and *parasitism*, as expressions of the normal relation of the two symbionts. His recent observations prove still more decisively the healthy reaction on each other of fungus and alga in the lichen thallus. For instance, in the study of a fungus gall on the scyphus of *Cladonia fimbriata* he found striking evidence of mutualistic growth. The fungus had settled on the edge of the scyphus and formed there a large complicated outgrowth. Meanwhile certain soredia on the inside of the cup showed increased development, the gonidia had multiplied enormously, especially the round sporulating groups. This great development of gonidia could only be explained, he holds, by the amount of water and nutritious salts provided by the fungus hyphae. On the other hand the fungus profited equally by the increase of assimilative (gonidial) tissue. Bachmann recognizes a true symbiosis with exchange of inorganic for organic material. Sections through the gall showed a dense "mosaic" lichen tissue formed also of the stimulated hyphae and the algae.

He cites further instances of mutual stimulus in more normal growth: in *Anaptychia ciliaris* var. *verrucosa* the thallus, as the

name implies, has a warted aspect. Underneath the excrescences there was found a great increase of the normal gonidial band, as well as of loose hyphal filaments. He concluded that these warts served as aeration bodies; he found points on the basal layer where occurred openings to the thallus below. Bachmann also describes the effect of normal and abnormal pycnidial development—abnormally on the under side of a squamule, normally on the upper side, but in both instances accompanied by increase in the size of the squamule. As before he affirms the balance of development between the symbionts: as the pycnidial hyphae induce the increase of water and inorganic salts, the alga responds by the multiplication of green cells with their greater activity of photosynthesis.

In *Catillaria* (*Biatorina*) *synothea* he noted that when pycnidia were to be formed the thalline tissue always increased in thickness. The gonidia that perish in these processes serve undoubtedly as nutriment to the hyphae; but Bachmann holds that this is not parasitism; the death of these cells is comparable to the death of individual cells in the growth of a tree; it is a sacrifice to the greater good of the lichen as a whole. He sums up that though the lichen may not be regarded as one individual, yet it presents a physiological entity with astounding solidarity of the two component organisms.

Morphology.

Isidial formation. In certain lichens belonging to widely different groups—crustaceous, foliaceous or fruticose—isidia are normally developed on the surface or edges of the thallus; they are small thalline outgrowths, fairly constant and mostly of conical form, simple or branched, and are of service to the plant in increasing the assimilative surface as they always include the algal symbiont; since they are easily broken off, they aid in propagation. Linkola had already studied the formation of the somewhat abnormal isidia of *Peltigera lepidophora**. He has now contributed a paper (1922) on the densely massed marginal isidia of *Peltigera rufescens* var. *praetextata*. These isidia which occur as a thick fringe on the margin of the lobes may arise also on the edges of a wound in the thallus; they have even been observed on the back of the apothecia and—though somewhat rarely—on the under surface. That isidia should develop from the edge of a wound does not seem surprising—it may be regarded simply as an act of regeneration—but Linkola claims that the development in this case is unique and is only met with in this *Peltigera*. In *Umbilicaria* it is known that isidia are associated with wounds, but in that case the isidia were

* See Lichens, p. 161.

there first and have brought about the break in the thallus. Linkola thinks that the occurrence of the isidia should give this lichen specific rank as *Peltigera praetextata*.

Einar Du Rietz in his "Systematic Studies" (1922) has also given notes on the soredial and isidial species of *Peltigera*. Concerning *P. praetextata*, he states that in young plants the isidia may be wanting, but he finds, as did Linkola, that they develop quickly on any wounded portion. He inclines to associate this lichen with *P. canina*, though in Britain it has always been classified as a variety of *P. rufescens*. He also judges *P. lepidophra* to be closely allied to *P. canina*.

Pleurocarpy and Pycnothelizy. Examples of abnormal growth in *Cladonia* have been signalized by Bachmann in two papers. The first (1923, 1) deals with the excessive multiplication of pycnidia in some species. He found that they originated from the cortical layer, from the layer between the cortex and the gonidial zone or from the gonidial zone itself. Those that developed on the under side of a squamule took origin from the medulla. In all cases the abnormal increase of these bodies was accompanied by a great development of the gonidial vegetative tissue. Bachmann gives the term "Pleurocarpy" to this condition which was first observed in *Cladonia gracilis* var. *pleurocarpa*.

A second unusual development of fructification first noted in *Cladonia fimbriata* var. *pyknotheliza* has been designated "Pyknothelizie" by the same author (1923, 2). The fructifications—pycnidia and apothecia—appear both on squamules and on podetia and are extremely abundant. The abnormal growth is, here also, accompanied by a corresponding increase of the vegetative tissue—the enlarged gonidial zone, larger squamules, and numerous soredia and isidia. Bachmann (1919) had recorded a similar excessive gonidial and vegetative development in *Parmelia physodes* in an unusual outgrowth with pycnidial development. The gonidia in that case also had increased enormously and were most of them surrounded by delicate hyphae.

Further work has also been done by Bachmann (1924) on unusual developments in *Cladonia podetia*. He has found that adventitious shoots are very common in ascyphous *Cladoniae* and that they arise from the gonidial meristem. In one case he found a new shoot associated with a gall in a podetium of *Cladonia cornuta*, in which instance the new shoot burst inwards and developed in the hollow of the podetium. It originated about 5 mm. from the tip and the intervening space was infected by the hyphae of the gall fungus. The shoot

was of reduced stature, probably owing to want of organic nutrition; it had no gonidia of its own and was entirely dependent on the nourishment provided by the gonidia of the host podetium. He states that had it reached the open it would doubtless have soon acquired gonidia from external sources which brings him to the affirmation that the podetial gonidia, as Krabbe believed, arrive from the open.

Another peculiarity of the adventitious shoot was the reduced amount of medullary tissue; its development for strengthening purposes being unnecessary. He noted also the unusual thickness of the hyphal cell-walls, the small amount of plasma in the outer hyphae of the medulla and along with these developments the change of the apical meristem to resting tissue. He explains all these phenomena by the lack of sufficient nutrition, that is, by the absence of gonidia with their contribution of organic material.

Bachmann previously was of opinion that the inner podetial medulla could not change to meristem; he now finds that even this unpromising tissue under the irritation of the fungus gall can become meristematic and aid in the formation of new shoots.

The excessive development of gonidial tissue in response to new demands had already been described by Bachmann (1919) in a study of fungal parasites on *Parmelia physodes*. Galls, with their increase of tissue, were formed where the fungus had attacked the thallus. He points out the relation between the fungal hyphae and the greatly increased gonidia of the lichen; at first, as in cases of "parasymbiosis," the fungal hyphae shared along with the lichen hyphae the nutrition supplied by the gonidia; but at a later stage the lichen hyphae were pushed aside by those of the parasite which then closed narrowly round the gonidia. The lichen hyphae were later attacked and absorbed by the fungus which, though parasitic in regard to these lichen hyphae, continued to live symbiotically with the algae.

Physiology.

Disintegration of glass and rocks by Lichen thalli. In a recent paper Ethel Mellor (1923) reviews the work already done by her* at the Sorbonne, Paris, on the damage caused by lichen growth to church windows. In summing up she attributes the corrosion to (1) the effects produced by the lichen acids, and (2) to the effect of carbonic acid dissolved in water. From one or both of these causes the glass is gradually weakened and perforation may occur. The first stages, she holds, are due to the colonization on the glass of minute, poorly-developed

* See Trans. Brit Mycol. Soc. VIII, p. 199 (1923).

crustaceous lichens. A small series of larger lichens—*Ramalina polymorpha* var. *ligulata*, *Xanthoria parietina* and its var. *tumida*—arrive at a later stage and aid the process of disintegration.

A somewhat different view of glass corrosion by lichens is suggested by E. J. Fry (1924). Her study of rock lichens had convinced her that the gelatinous substance of lichen hyphae, more especially of the attaching rhizoids, probably acted mechanically on rocks and on glass in the same way as a gelatine film. She cites the known fact that when a solution of gelatine is spread over a glass plate and dried quickly, the gelatine contracts and curls up at the edges in the process of drying; and its hold is so fast that comparatively large shell-shaped portions of the glass are torn from the surface. She carried out a series of experiments with gelatine on glass and on shale, and in both instances a film of the substratum adhered to the drying and contracting gelatine. Attention was then directed to the action of lichens on smooth unweathered and unaltered shale. A portion with a lichen attached was moistened and dried again, one or more times; examination showed that thin films of the rock adhered to the lichen. E. J. Fry therefore considers that the first process of disintegration is due to this mechanical action, and only later are the separated fragments decomposed by acids.

Water storage. Bachmann had studied the water-content of immersed limestone lichens. He has now (1923, 4) published the results of a study as regards water-storage of those that live on hard siliceous rocks. He finds that the foliose lichens, *Umbilicaria pustulata* and *Gyrophora* spp., have a capacity of water absorption and retention much greater than that of crustaceous lichens. In the case of *Umbilicaria* it is due to the pustulate character of the thallus; in *Gyrophorae* the water is stored and held in the dense medullary tissue. In crustaceous silicicolous lichens water is absorbed in various ways; in some it is in the "hyponecral" zone, that is the zone beneath the gonidial layer which contains many sheaths of empty gonidia, these sheaths serving as reservoirs for water. Water escapes from such lichens more rapidly than from limestone species which are more or less embedded in the rock. Easily-broken rocks—roughened on the surface—seem to encourage the growth of a thick type of thallus with its enlarged capacity of absorbing water, and the thick cortical layer of disorganized cells present in many of these forms certainly delays evaporation. In lichens such as *Placynthium nigrum*, the largely developed hypothallic structures retain water. Some lichens, such as *Rhizocarpon*

geographicum, spread widely over the hard stone in a thin layer and without any special storage structures, but such lichens have a special capacity of retaining life during long periods of drought, as do the desert lichens. In the preface to Bouly de Lesdain's supplement to *Lichens du Mexique* (1922) it is stated that on the high Mexican plateaux there are two seasons; from the end of May to October, when rain falls in torrents every day, and the alternative six months which are dry. All through the dry months lichens support direct insolation and an extremely dry atmosphere; they are both varied and abundant, but if collected during that period they fall to powder in the hand.

It is well known that blue-green lichens and algae also manage to exist in extreme desert conditions. H. H. Thomas, in his study of Libyan plants (1921), records an instance of this: he found a lichen, the algal constituent of which was a *Gloeocapsa*, growing closely attached to a pebble in full insolation and in company with colonies of the alga. The lichen was brought home and was still living under laboratory conditions after a period of five years.

Cells and cell-contents. Salkowski (1920) has made a study of carbohydrates and the fermentative products of the lichen cell; he tested the hemi-celluloses of *Lichen islandicus* and *Cladonia rangiferina* by hydrolysing air-dried material with sulphuric acid (H_2SO_4). As a result he obtained 60 per cent. fermenting sugars. Sodium chloride, in strong concentration, restrained fermentation and more effectively with high percentages of sugar. With only 12 per cent. of sugar and 4 per cent. of sodium chloride fermentation was complete. Diastatic ferments did not destroy sugar in lichenin. Some substance that hindered fermentation was detected, probably a lichen acid. The content of cetraric acid was reckoned to be at least 10·92 per cent. of the air-dried substance.

A criticism of Mameli's views on lichen starch has been contributed by Cengia-Sambo (1923). He did not find starch in the gonidia; in these bodies the first product of assimilation was oil, but he does not attempt to explain the process of primary oil-formation.

In the membranes of the gonidia he found the carbohydrate present to be amilodestrin. With free *Protococcus* algal cells he got the same reaction for amilodestrin, viz. rose-violet on the application of iodine, but in these he demonstrated the presence of starch.

In his study of the asci he made use chiefly of *Anaptychia ciliaris*; in the early stages he distinguished three layers in the ascus membrane: an outer membrane of amyloid structure,

within that a layer of glycogen, and a third more granulose protoplasmic layer which provides for spore formation. As development proceeds the glycogen becomes transformed to oil which serves as nutrition for the spores. The oil reserve within the spore serves to nourish the germinating hypha.

As regards photosynthesis, Henrici (1921) states that in lichens as in other plants there are light and shade forms, and that if extreme shade lichens are exposed to strong light, assimilation ceases altogether. He found that the light optimum for lichens was lower in the shade forms.

Lichen acids. New facts regarding the chemistry of lichen acids are recorded by Hepworth (1924) in his book on organic products (chap. IV). Compounds with tannin-like properties had been investigated by Fischer and had been termed by him "Depsides" from the Greek, to tan. Lichens are the only natural source of the depsides so far discovered. Three acids associated with depsides are orsellnic, lecanoric and everninic, and all three have been synthesized by Fischer or by Hoesch. Vulpinic acid, which occurs in *Letharia vulpina*, was synthesized in the laboratory by Volkard* in 1894, the only instance of the synthetic preparation of a lichen acid previously recorded.

Use of reagents. There is not much to record under this heading. Anders (1923) gives a note with regard to the necessity of care in applying the reagents in *Cetraria hepatizon*; on the application of potash the medulla of the thallus gives a yellow colour which becomes red only after some hours. Magnusson (1924) recommends the use of potash in studying the formation of the apothecium and the septation of the paraphyses. The sections after such treatment may be washed and then neutralized with sulphuric acid (dilute); the addition of iodine will make clear the lumina of the cells, the texture of the hyphae, etc. In testing with potash (K) he is accustomed to place a thick section on a slide in a drop of the solution. "If there is a positive reaction of yellow then red is expected, a yellow mist will be formed first in which thin rusty needles appear." In examining with CaCl he scrapes off a bit of the thallus with the wetted point of a knife, mounts it in a drop of water and adds a grain of calcium hypochlorite (bleaching powder). In a few seconds the colour will appear. Magnusson has found—as others have done—that the reaction with potash cannot always be relied on.

Bionomics.

Rate of growth in Lichens. Several papers within recent years have dealt with the somewhat debated subject of the rate

* Lichens, p. 228.

of growth in lichens. Linkola (1918) has recently carried out measurements on the rate of growth of *Parmelia* spp. in Finland which confirm the observations of previous workers. The measurements were made at intervals of one year between the autumns of 1910–11 and 1911–12, and then at a longer interval, 1912–16. He gives the average of the three tests for each species. The results of growth for a year were: (1) *Parmelia sulcata*, 1–6 mm.; (2) *P. centrifuga*, 2·5 mm.; (3) *P. olivacea*, 0·7 mm.; (4) *P. physodes*, 1·6 mm.; (5) *P. ambigua*, 0·7 mm. and (6) *P. aleurites*, 0·7 mm. These lichens grew on palings, except *P. centrifuga*, which was found on granitic rocks. Comparing the size attained by the lichens with the rate of growth, he concluded that No. 1 would be 30–40 years of age; No. 2, 50–80 years; No. 3, 50–60 years; No. 4, 30–40 years; No. 5 (*P. ambigua*, on which shade conditions had reacted unfavourably), 15–20 years; and No. 6, 20–25 years. Linkola thinks that the limit of age in Finland had been reached by these species.

There are also records on the origin and growth of lichens by Tobler (1920, 2). He studied more particularly the development of *Cetraria* on *Fagus* and *Picea*. The chief means of propagation was by soredia and he considered that a composite plant might, and did, arise by the mingling of several soredial individuals. The calculation of yearly growth is thus a little complicated and must be taken from the point of origin and not the whole width of the thallus. The lichen developed more easily on *Fagus* than on young growths of *Picea* owing to the different characters of the bark; the rate of growth was however practically the same—about 1 cm. increase of the young thalli in the year. This is a much higher estimate than that of Linkola; but the latter was dealing with long-established plants of mature growth.

Substratum. An interesting study on the relation between lichens and their substratum in the case of those that grow on bones has been contributed by Bachmann (1920). He studied the exact manner of growth of a number of crustaceous species, all of which were erratic on bones. He divides them into two classes, "exostitisch" and "hypostitisch," according to their lodgment without or within the substratum. He found that in no case did they draw any nutrition from the osseous tissues, but that the bone, owing to its porosity, not only gives shelter to the thallus (when it is "hypostitisch"), but also receives and retains water which is a distinct advantage to the lichen. The lichen hyphae he decided had no power of boring channels, as in limestone; the growth is purely superficial. He speculates on the question as to whether endolithic lichens, such as some

Verrucariae, might not retain their boring power if transferred to bone. Bachmann cites the case of fungus hyphae having been found in fossil bone; but the living example of *Onygena equina*, which grows only on bones, might prove still more instructive, as of necessity the fungus there is dependent on the bone for nourishment.

Magnusson (1924) found that *Acarosporae* are extremely selective as to their substratum; most of them grow on granitic or siliceous rocks, a few are as exclusively calcicolous. Those that avoid limestone are to a large degree nitrophilous lichens: *A. fuscata*, *A. nitrophila* and *A. peliocypha* inhabit by preference the summits of rocks where birds congregate, or the lower slopes washed by water charged with the excreta. He noted that *A. fuscata* collected from a situation deprived of nitrogen supply had a thinner, lighter-coloured thallus and was mostly sterile. Other *Acarosporae* grow where there is a plentiful supply of dust laden with nitrogenous particles, such as road sides or the proximity of barns. Several species of aquatic or semi-aquatic habit are also presumably nitrophilous. One species, *A. insolata*, he records as seemingly non-nitrophilous, but it lives intermixed with other crustaceous lichens and may obtain nitrogen from its associates; he compares it with *Lecanora atriseda*, which destroys *Rhizocarpon geographicum* and then lives saprophytically on the dead thallus.

Ecology, Distribution and Systematy.

These three aspects of plant study are so closely connected that it seems best to consider them together. It has not previously been thought advisable to include purely systematic works, but many of those recently published contain valuable notes on distribution as well as on ecology.

Polar Lichens. From the far south there are two records by Darbishire, both published in 1923, (1) of lichens, collected in 1910 by the Terra Nova, and (2) Cryptogams brought home by Sir Ernest Shackelton's Expedition. The latter collection includes some 15 species, one being new to science; they were found on the slopes of Mt Erebus or on Elephant Island. In the former more important paper Darbishire reviews the present position of our knowledge of Antarctic species, more especially as compared with Arctic. Hue in his work on the French Antarctic collections (1903–5 and 1908–10) had found and described so many new plants that he came to the conclusion that the lichen flora of Antarctica was largely unrelated to that of any other region*. Darbishire concedes that Hue's experience

* See Lichens, p. 347.

somewhat alters his previous percentages of common forms, but again points out the remarkable similarity between the lichens of the polar areas. He tabulates these in their relation to the two poles as follows:

Fruticose lichens: 12 in common or 44 per cent. of the whole number.

Foliaceous lichens: 9 in common or 32 per cent.

Crustaceous lichens: 28 in common or 18 per cent.

The highest percentage is thus to be found in fruticose or shrubby lichens, and seems, Darbishire considers, to indicate the greater antiquity of these highly developed forms. In the Terra Nova material were 17 lichens, 9 of which were new species, 7 of them belonging to the genus *Buellia*. Most of these polar lichens are characterized by a very dark thallus and predominating black hypothallus, though brighter tints, especially yellow, are not wanting.

Spitzbergen, which lies well within the arctic circle, was visited in 1921 by members of Oxford University, and the lichens which were collected by V. S. Summerhayes were examined and determined by R. Paulson (1923). The specimens represented 27 genera and 68 species, most of them ground or rock dwellers, and most of them healthy and abundantly fertile, with the gonidia sporulating freely. *Cladoniae* ranked high in point of numbers both of species and individuals—*C. pyxidata* perhaps the commonest of all, though often starved and deformed. Paulson particularly notes the ubiquitous nature of *Lecanora tartarea*, which takes fantastic forms as it spreads over other vegetation.

Lichens of temperate zones. Bouly de Lesdain (1924) has described the flora of a district on the dunes of Belgium, chiefly an alder thicket and the "möeres," which are dried up lakes. The whole district is drying owing to drainage, with the consequent disappearance of trees and of atmospheric moisture. Most of the lichens were epiphytic on the trees of the thicket. In his general remarks he notes that *Parmelia* and *Ramalina*, that grow on isolated trees in colonies, were, in the wooded area, of much sparser growth. *Parmelia physodes*, common enough on old wood in the immediate neighbourhood, failed altogether on the isolated trees and was rare in the thickets. Lesdain chronicles 90 lichens for the district, several of them new species or varieties.

A paper published by F. Erichsen some years ago (1916) gave an interesting account of the lichen vegetation on the sand-dunes of the German coast. Near Neustadt, in Holstein, there occurs a stretch of dunes known as the Pelzerhaken; they do

not reach any considerable height and are thickly interspersed with boulders and flints of varying size. Erichsen recognized there five distinct zones of vegetation; in the first zone nearest the sea, and often covered with the tide, he found only one small thallus of *Verrucaria halophila*. The two succeeding zones were occupied mostly by halophytes; the stones—chiefly flints —were subject to rolling caused by the higher tides and only small beginnings of lichen thalli had found a footing on them. The fourth zone, with its more firmly embedded stones and stable soil, gave a rich harvest of dark-coloured crustaceous forms—among the more abundant *Buellia aethalea* and species of *Rhizocarpon*, with various soil species, such as *Cladoniae*. It was noticeable that even grey forms like *Cladonia sylvatica* shared in the brown coloration and had developed brown tips on the branches. Between cushions of moss there spread the dark thalli and apothecia of *Lecidea uliginosa* and *Bacidia muscorum*. Lichens of a gayer colour were not entirely absent; yellow *Xanthoriae*, dove-gray *Physciae*, *Parmeliae* and *Lecanorae* being fairly abundant. A marked feature in all these lichens was the dwarfed character both of thalli and fructification. Erichsen listed 59 species from the area.

A very different type of locality is dealt with by C. P. Hurst (1923) in his *East Wiltshire Lichens*. His chief hunting ground was Savernake Forest and the surrounding country. The absence of rocks explains the fact that only one *Lecidea* is listed —the very common corticolous *L. parasema*. Corticolous species of other genera, as was to be expected, are well represented, not only the crustaceous, but also the more highly developed foliose or fruticose forms.

Jos. Anders (1923) has described the lichens in the Isergebirge. The highest point of the range, the Tafelfichte (1122 m.), is entirely covered with pine woods and on stems, branches and stumps he found in great abundance the rather rare lichens *Parmeliopsis aleurites*, *P. ambigua* and *P. hyperopta*; among crustaceous species *Lecanora symmicta*, *L. argentea*, etc., and *Mycoblastus sanguinarius* were abundant, the latter very noticeable where the thallus had been frayed, thus revealing the blood-red tissue below the apothecia.

The Carpathians have been examined from an ecological point of view by Jindrich Suza (1922) in his *Lichens of the Těšínsko Tchécoslovaque in Eastern Silesia*. The mountains attain a height of 1000 m. on the southern side, declining towards the north to a high plateau. There is much humidity in the forests at the summits of the mountains and the epiphytic lichen flora is very rich, but only in individuals; there is no great variety of species. Comparison is made between the lichens on

Picea excelsa and on *Fagus sylvatica*. On the former are to be found several species of *Cladonia, Sphaerophorus coralloides, Parmeliae*, etc., with *Mycoblastus sanguinarius*, but none of the *Trentepohlia* lichens—Graphidaceae, etc. On the beech with a smoother bark, no *Cladoniae* were found, but various *Parmeliae*, a few *Graphideae* and other crustaceous species. Several were common to both types of tree trunk.

Charles Plitt has studied the lichen vegetation in four ecological stations at Mount Desert Island, Maine, U.S.A.; these are designated: (1) the White Pine station; (2) the Pitch Pine station; (3) the Spruce station; and (4) the Oak station.

The White Pine (1), at an altitude of 200 ft., consisted almost solely of *Pinus Strobus*. *Cetraria lacunosa* and *Parmelia physodes* were almost equally abundant on the trees; next in quantity, *Nephromopsis ciliaris*. A list of 41 lichens was made at this station in the order of their frequency.

Pitch Pine station (2) is situated at an altitude of 650 ft. and a great change was noted; only a bit of *Cetraria lacunosa* was found and a bit of *Nephromopsis*. Here *Parmeliopsis aleurites* and *Mycoblastus sanguinarius* vied with each other for supremacy. A list of 37 species was made.

Spruce station (3) (80 ft.) showed a still greater change; the branches of the trees were festooned with *Usnea* and the trunks decorated with *Lobaria pulmonaria* and *Pertusaria amara*, while *Peltigera polydactyla* formed large rosettes on the moss-covered ground. Some 29 species were listed here.

The fourth or Oak station was poor in lichens, only 21 species being collected; the most common of all was *Conotrema urceolatum*; every oak that had retained smooth bark had "a liberal growth of this lichen."

Plitt visited later another White Pine forest in order to compare the lichen growth with that of the "White Pine" station. There was a considerable admixture of Spruce, but here again *Cetraria lacunosa* was most conspicuous. There was scarcely a tree of *Pinus Strobus* on which the lichen was not present, though it was scarcely ever seen on the Spruce. It was quite possible in this forest to distinguish between these trees by the lichen growth.

Still another study of lichen growth has been undertaken by C. Plitt and Louis J. Pessin (1924). They have sought to determine the correlation between the evaporating power of the air, the intensity of the light, and the distribution of the lichens along the height of a tree and around its circumference. The experiment was made on a tree (*Quercus rubra*) a little over 13 m. in height and about ½ m. in diameter at 2 m. from the ground. It grew on Mount Desert Island, Maine, in rather dense woods and was fairly well covered with lichens: 28 different species

were determined. The tree was divided into zones; the lichens in each zone were enumerated; light and moisture were tested at regular intervals.

The writers found that the evaporating power of the air was the chief factor in the distribution of the lichens; it was found to be of much more importance than the intensity of light. Certain plants, such as *Leptogium tremelloides*, *Pertusaria amara* and *Lobaria pulmonaria*, only occurred in areas of low evaporation; species of *Usnea* and *Ramalina* only where evaporation was high and light intense. *Xanthoria parietina* was found in only one patch near the top of the tree on the north-west side, though *Xanthoria* is essentially a sun-lichen.

Tropical Lichens. In an account by Malme (1922–3) of lichens collected in the first Regnell Expedition to South America, special emphasis is given to the influence of moisture as well as of temperature on the growth of these plants. He found, for instance, that the flora in the coastal regions—Rio de Janeiro, Santa Catharina, etc.—differed widely from that of Matto Grosso, an inland locality. He cites as evidence the presence of only a few species of Stictaceae in the central region, while at the coast they were in great numbers both of individuals and species. It was the same with the genera *Ramalina* and *Teloschistes*; of the latter he says, indeed, no species was collected in Matto Grosso. Crustaceous species also differed widely in the two regions.

Another paper touching on the lichens of tropical lands is that of William Seifriz on the ecological survey of Mt Gedeh, Java (1923). He divides the mountain into four botanical zones: the first of these at an altitude of 4600–5500 ft. is characterized by its big trees and somewhat open ground. The great trunks in that region were sometimes completely covered with lichens, giving to the bark the appearance of an elaborate mosaic; *Graphideae* and *Pertusariae* were well represented. The foliose genus *Sticta* was also in abundance. The next highest zone (5500–7000 ft.) was a forest and fern area; the trees were profusely draped with mosses, and the lichens were either crowded out, or their development was inhibited by the absence of light, lichens being peculiarly sun-plants. From 7000 to 8000 ft., designated as a herbaceous zone—an open and sunny region—mosses were absent and lichens were again numerous, *Usneae* being specially luxuriant. The *Vaccinium* zone, nearest the summit (8000–9000 ft.); was also characterized by many lichens, most of which had not appeared in the lower zones. A species of *Cetraria* was "the most common at this altitude, growing in large fluffy cream-coloured patches."

Also from Java comes a first paper on the ecology of epiphytes by Paul van Oye (1924). The paper so far deals only with four host trees: *Bambusa*, *Oreodoxa regia* (Palm), *Areca Catechu* and *Cocos nucifera*. Among bamboos those trees that grow in the open are most covered with epiphytes, chiefly lichens.

On *Oreodoxa* the epiphytes were again mostly lichens with a few other growths of mosses and orchids. The lichens were larger and more developed than those on *Bambusa*. The stem of *Oreodoxa*, rather slender at the apex, suddenly widens out some way below; on this larger surface the lichens are seated, their growth being favoured by the water which after trickling down the narrow part spreads over the enlarged area.

Areca Catechu. Any lichens found were mainly on old and dry stems; the epiphytes on normal trees were chiefly mosses and *Trentepohlia*.

Cocos nucifera. On this tree there were even fewer lichens, but *Trentepohlia* was abundant.

Geographical distribution. Suza (1922) records an arctic lichen, *Nephroma expallidum*, in the High Tatra (Czecho-Slovakia) and compares it with the presence of other arctic lichens, such as *Parmelia centrifuga* and *Cetraria odontella* in Central Europe, though not in the Alps. He concludes that these lichens are relics of the glacial period. A more astonishing record is that of *Usnea sulphurea* (*Neuropogon melaxanthus*) on the coast of Norfolk, recorded by Maheu and Gillet (1923). In that case the lichen probably had been brought by a ship from some far distant polar area; it can hardly be regarded as a British species. In contrast with the high altitudes we have the work of Jozef Motyka, also in the Carpathians, but in the valley Kosueliska, on the western side of the Polish Tatra. His attention was given to forest species, to those of alpine prairies, and to the forms growing on siliceous rocks. The district must be typical of temperate Europe, as there is an astonishing similarity between the lichens of the Tatra and those of the British islands, though on the whole they correspond rather with those of our hilly districts. Graphidaceae are very poorly represented, while *Cetraria*, a truly northern genus, furnished 13 species.

An important paper has been contributed by A. Zahlbruckner (1924) on the lichen flora of Juan Fernandez. The "Robinson-Inseln" has had a romantic interest since Defoe's day, and recently the natural history has been thoroughly explored by a Swedish expedition under the direction of Carl Skottsberg, who, with the help of his wife, made large collections of lichens along with other plants. Zahlbruckner has collated with these the records of previous workers:— Bertero's collection examined by

Montagne; W. J. Hooker's lichens described by T. Taylor; the material of the Challenger expedition, of which Crombie had charge, etc. The list for the island now stands at 185 species, and these, divided according to the algal symbiont, are: combined with bright green (Protococcaceae), 109 species, or 60 per cent. of the whole; with blue-green algae, 48 species, 25 per cent.; with *Trentepohlia*, 28 species, or about 15 per cent. Zahlbruckner finds the lichen flora to be partly Chilian in origin and partly subantarctic American. He describes a considerable number of new species—so far endemic, but possibly to be found elsewhere. As compared with the lichens of Samoa, which also were worked out by him, he notes a considerable falling off in lichens that are combined with *Trentepohlia*, these being generally abundant in the tropics; the high percentage of blue-green lichens remains about the same, that type of lichen being peculiarly a denizen of volcanic islands.

More definitely tropical are the lichens of the Philippine Islands, a large instalment of which have been published by Wainio (now Vainio) (1921). A very large number of new species have been determined as well as new genera. It is interesting to find here also the large percentage of Phycolichens (blue-green) and to note the predominance of tropical genera, such as *Thelotrema*, *Sporopodium*, *Graphis*, etc.

An exhaustive work on Finnish lichens is in course of preparation by Vainio. Two sections have already appeared, the first, which comprises the Pyrenomycetes (1921), is extremely welcome, as Th. Fries in his fine work on Scandinavian lichens did not include that group. In the second (1922) he takes up Baeomyceae and Lecideales. Under the former there is only one genus, *Baeomyces*; the sub-tribes Cladoniae and Lecideales follow. He enumerates 45 species of *Cladonia*, a genus very abundant in northern regions. The Lecideales are unfinished. Vainio has substituted for *Lopadium* an older name, *Sporopodium* Mont. The remaining parts of this great work will be eagerly anticipated.

A. Magnusson (1924) has just completed and published his monograph of Scandinavian *Acarosporae*. The genus is characterized by the many-spored asci, the spores being mostly very small bodies. In our own islands we have a record of 12 species; Magnusson describes 35 for his territory, but 9 of these are new to science and his own discovery. *Acarosporae* almost exclusively inhabit rocks and are to be found, rather monotonously so far as Great Britain is concerned, in "maritime or upland" regions. There is one fairly common and brightly-coloured species, *A. chlorophana*, which has not been reported in the British Isles, though it extends well over the continent. Mag-

nusson says: "As far as I know *A. chlorophana* always grows under overhanging rocks, where it may cover large areas more or less densely with its conspicuous yellow thallus, and therefore it has been noticed from numerous localities."

The contribution by Savicz (1924) on the *Cladoniae* of Kamtschatka contains much that is valuable on the distribution of the genus. Thirty-seven species have been determined with numerous varieties, some of them new to that region or new to science. They belong chiefly to the "circumpolar" group and are an important part of the vegetation, especially on the "tundras" of the sea-coast, where species of *Cetraria, Thamnolia, Sphaerophorus, Bryopogon* and *Nephroma arcticum* cover enormous areas.

Of the three "reindeer mosses," *Cladonia rangiferina, Cl. sylvatica* and *Cl. alpestris*, it is the last mentioned that is the most abundant on the mountain "tundras." Savicz is inclined to the belief that it is also the species that is most sought after by the reindeer. Bernt Lynge has told us of its extensive use as fodder in Norway. Savicz also notes the peculiarly white colour of this lichen in Kamtschatka.

Systematic notes. Einar Du Rietz in his *Lichen Systematic Studies* (I, 1922), after careful work, has given specific status to a lichen not uncommon in our own upland rock districts, but listed hitherto as *Cladonia lepidota* form *hypophylla*. It was described by Crombie (Monogr. I, p. 16 *a*) as most probably referable to *Cl. cervicornis*, and by myself (Monogr. I, ed. 2, p. 438) as "a very peculiar form, the podetia having the appearance of enlarged squamules" and "apparently very near to some growth form of *Cl. cervicornis*." Its frequent and abundant growth in Scandinavia, always in characteristic form, induced Du Rietz finally to place it in a separate species as *Cl. subcervicornis* DR.

A new species is also described in Study II (1922), *Leptogium Sernanderi*, a rare form belonging to the bluish- or leaden-coloured section of the genus. His views on *Leptogium* spp. do not always coincide with those of British lichenologists: we consider *Lichen cochleatus* Dicks. as undoubtedly synonymous with *Leptogium iremelloides*, renamed *L. cyanescens* by Du Rietz, who refers it to *Collema rivulare*. In his third contribution (III, 1924) he finds two species described under *Cetraria lacunosa*; the one familiar to us in Britain, bearing isidia, he classifies as *C. norvegica*, the true *C. lacunosa* being, he finds, an American plant without isidia.

A monograph of all known *Crocyniae*, prepared by Abbé Hue before his death, has been edited and issued by Bouly de

Lesdain (1924). It concerns an obscure genus of lichens of which only one, a tropical species, *Crocynia gossypina*, has hitherto been known as fertile. A new species with fructification, *C. antecellens*, has recently been found in southern France. A very large series of species formerly considered as imperfectly developed thalli and sometimes placed in the old genera, *Lepra* or *Lepraria*, are now definitely diagnosed and described as species of *Crocynia*. Quite a number of these are British. In the introduction to the paper Lesdain justifies the present publication, though indicating that further work may probably lead to more close grouping. The giving of definite specific rank to so many sterile thalli, several often from one locality, tends to fill the systematist with dismay, but more experience may reconcile one to the French point of view.

Charles Plitt has published a diagnosis and description of a new species of *Crocynia* from California. A number of *Crocyniae* have been described on thalline characters, as stated above, most species being sterile. Plitt has drawn out a table of all those species with Protococcaceous gonidia, none of which agree with his specimen. An interesting peculiarity is that the thallus is dotted with minute red specks which proved to be scale-insects. Plitt notes that *Crocynia maritima* B. de Lesd. is characterized by red specks and suggests that these also may be due to the presence of insects.

Among authors with different views there is a constant shifting in classification of doubtful species from lichens to fungi and from fungi to lichens. Of late years the tendency has been to classify all these doubtful forms as fungi. Bachmann (1923, 5) has reversed the process in the case of *Bactrospora dryina*, first described as a lichen, but which, for some time, has been placed among the Discomycetes as a member of the Patellariaceae. The structure has been examined by microtome sections, and the bark on which it grows has been found to contain a very healthy and well-developed thallus, mostly however within the bark. He claims that *Bactrospora* is an undoubted lichen.

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STUDIES IN ENTOMOGENOUS FUNGI.

(With Plate X and 1 Text-fig.)

VI. CEPHALOSPORIUM AND ASSOCIATED FUNGI.

By T. Petch, B.A., B.Sc.

A. *Cephalosporium* (*Acrostalagmus*) *Lecanii* Zimm.

This fungus appears to have been first observed in Ceylon about 1861. Nietner, in his pamphlet on *The Coffee Tree and its Enemies*, published in that year, stated: "It has been mentioned to me that the bug was subject to a disease—a white covering forming over it and destroying it. This is simply mould." The "bug" was *Lecanium coffeae*.

The fungus was subsequently found by Zimmermann on *Lecanium viride* on coffee in Java, and was briefly described by him under the name *Cephalosporium Lecanii* in a short paper in 1898. He stated that each dead scale was surrounded by a white fungus which consisted of fine hyphae radiating from the scale over the surface of the leaf for a distance of about 1 mm. The hyphae gave rise to short lateral branches, each bearing at the apex a large number of conidia, which were united by slime into a sphere. If, however, the sphere was placed in water, the slime dissolved and the conidia separated. The conidia measured $3{\cdot}5 \times 1{\cdot}5\mu$.

Zimmermann cultivated the fungus on nutrient agar, but as the object of his paper was to direct attention to the possibility of utilising the fungus to control the scale insect he did not give further details.

In a later publication (1901), Zimmermann stated that he obtained very strong cultures on a medium consisting of 2 per cent. agar, 1 per cent. peptone, 4 per cent. cane sugar, and 0·5 per cent. Liebig's meat extract. The fungus grew very slowly, being first visible to the naked eye after about five days, spores being produced on about the eighth day. The mycelium was at first white, and subsequently became yellowish.

Zimmermann recorded that he had received specimens from Mr E. E. Green in Ceylon which were identical with the Javan species.

Parkin, in 1906, recorded *Cephalosporium Lecanii* from Ceylon on *Lecanium viride, L. hemisphaericum* and *L. nigrum*. His account is as follows:

"The fungus shows itself to the naked eye as a white or pale yellow powdery bloom around, and to some extent over, the scales. The powdery or mealy appearance is due to innumerable conidial heads covering the hyphae. The external part of the fungus develops as follows: Hyphae radiate out on all sides from below the scale for a millimetre or more over the leaf surface. Each hypha produces at frequent intervals short lateral branches, the conidiophores, 16–20μ in length. Each conidiophore bears on its apex a spherical head of conidia enveloped in mucilage. This head, with a diameter of 4μ, appears when dry as a glistening globule, the individual conidia not being distinguishable. On treatment with water the mucilaginous matter dissolves and the conidia are dispersed; sometimes the last produced remains attached to the tip of the hypha. In order to examine the conidia *in situ*, the fungus should be mounted in dilute acetic acid, which prevents the mucilage from dissolving and renders the conidia visible. Five to seven are usually present in one head. They are really abstricted from the conidiophore in succession, but instead of remaining in a chain become aggregated together into a spherical mass by the mucilage which is secreted. Some infected scales kept in a damp atmosphere showed conidiophores bearing conidia in short chains, owing perhaps to mucilage not being able to mass them together*. The colourless conidia are minute, measuring 3·5–4 × 1·4μ, figures almost identical with those given by Zimmermann for the Java form. They are shortly cylindrical or nearly oval or slightly sausage-shaped.

"The conidiophores may be so numerous that here and there the mucilaginous heads, which touch one another, fuse to form larger masses of conidia.

"The lateral branches of the main hyphae which here are

* This is another species.

termed conidiophores may even branch themselves, so as to produce two to four heads of conidia.

"If a scale from affected material, but with no external fungus visible, be removed from a leaf and placed on a microscopic slide in a damp chamber, the development of the conidial part outside the insect can be readily followed. After one day the radiating hyphae proceeding from the margin of the scale were just visible: after two days the first conidiophores appeared, and after four or five days the whole insect was surrounded by a fringe of hyphae bearing numerous conidial heads.

"An example of *Cephalosporium* parasitic on *Lecanium hemisphaericum* var. *coffeae* on the stem of *Jussiaea suffruticosa* possessed a few perithecia. These were resting on the peripheral part of the fungus, and were globular in shape and pale yellow in colour. The long asci within unfortunately showed no definite spore formation and so were most likely immature. However, their presence points to the probability of this *Cephalosporium* being a conidial stage of some genus of the *Hypocreales*, to which group nearly all the other Ascomycetous scale-fungi described belong."

This species is very common in Ceylon on *Lecanium viride*, especially on coffee. It has also been found in Ceylon on *Lecanium nigrum, L. hemisphaericum, L. coffeae, L. expansum, Ceroplastes* sp., and a black *Aleyrodes*. Specimens from south India on *Lecanium viride* on coffee are identical with the Ceylon form. Mr W. W. Froggatt has kindly forwarded me specimens from New South Wales, on *Lecanium oleae* on *Phormium tenax*, and I am indebted to Mr G. H. Cunningham for specimens on a scale insect on *Citrus* from New Zealand.

On *Lecanium viride* the hyphae of the fungus grow out from beneath the scale over the surface of the leaf and form a thin white border about a millimetre wide. The hyphae are in part aggregated into strands, and consequently the film is at first distinctly radial in structure with a fimbriate margin. On these repent hyphae, short, erect, simple conidiophores, up to 25μ high, are produced at varying distances, usually solitary, but sometimes in pairs, and sometimes three together. The conidiophores bear globose heads of conidia, from 6 to 30μ in diameter. When two or more conidiophores arise close together their heads may fuse into a large continuous mass of conidia, up to 100μ broad. The white patch at first appears pulverulent, owing to the presence of innumerable conidial heads, but ultimately these all coalesce, or sink down to the base of the conidiophores, so that the patch is covered with a uniform waxy-looking layer of conidia.

Groups of conidiophores also break out through the scale and

form small compact patches. The mycelium surrounding the scale grows up over it, and under favourable conditions unites with the erumpent patches to form a film which entirely covers the scale. This covering may be even, or may be elevated in minute tubercles here and there, especially at the margin of the scale.

The hyphae which overrun the scale are densely interwoven into a thin, tough film. They bear conidiophores like those in the marginal film on the leaf, but, as the film is more or less plectenchymatous, these stand closely packed side by side and form a layer resembling the sporodochium of a *Tuberculariа*. This layer is at first minutely tomentose, but ultimately it becomes smooth and waxy, owing to the development of conidia and the fusion of the conidial heads.

In some instances the fungus does not spread out over the leaf, but forms a narrow, compact border, even or irregularly pulvinate round the margin of the scale.

The development of the fungus on other species of *Lecanium* is similar to the foregoing, but the mycelium does not appear, in general, to break out on the upper surface of the scale. The film which covers the scale of *Lecanium nigrum*, for example, appears to grow up over it entirely from the margin. In some cases this film can be peeled off.

The fungus is at first white, but finally becomes pale yellow or lemon yellow. In very wet weather it may form a loose mass over the scale, instead of a compact stroma, and this remains permanently white. The same loose growth may occur when scales which bear the yellow stroma are kept in a damp chamber.

The repent mycelium is regular, septate, 1·5–2·5μ diameter. The hyphae coalesce laterally into radial strands.

The majority of the conidiophores are simple, 10–25μ high, 1·2–1·5μ diameter below, tapering upwards more or less regularly to the acute apex. They arise from the repent mycelium, either scattered, or two or three close together, and stand erect or oblique, either straight or slightly curved. In specimens on the more convex scales, *e.g. Lecanium nigrum*, the conidiophores in the film which covers the insect may be more flask-shaped, up to 2μ diameter below, with a comparatively long thin apex.

In addition to the simple conidiophores, there is usually present a varying number of branched conidiophores. These may occur in the film on the leaf, where the conidiophores are scattered, or in the compact layer over the insect. Sometimes the compact film produces a small, white, rather loose tuft, which consists chiefly of branched conidiophores. When, however, clavate tufts up to 0·5 mm. high occur, these generally contain another fungus in addition to the *Cephalosporium*.

The simplest branched conidiophores (fig. 5) have a main stem about 24μ high, with a single lateral branch, arising just below a transverse septum, about 6μ from the base. Others have two opposite branches at about the same height. These might be regarded as branched simple conidiophores, except for the fact that the lower part of the stem is 2μ diameter. Others are 30–36μ, sometimes up to 64μ, high, with a stalk 2·5–3μ diameter below, and two or three whorls of branches, the lower of which may branch again (figs. 6–8). The lateral branches are 10–15μ long, and more flask-shaped than the simple conidiophores, owing to their greater diameter (up to 2μ) and a gradual attenuation towards the base. These larger branched conidiophores have a stumpy appearance. They do not stand out individually above the general level of the fungus.

In culture the branched conidiophores are longer, up to 110μ, with a slender stalk, 1·5μ diameter. They do not bear many whorls of branches, sometimes only one whorl of three branches near the apex, with paired or scattered branches below, sometimes two or three whorls at distances of about 16μ (fig. 9). The lateral branches are up to 12μ long, narrow flask-shaped, 1·2μ diameter. The simple conidiophores in the same culture are 12–24μ long.

The head of conidia is globose and may be from 6 to 30μ in diameter. The conidia are abstricted apically from the conidiophore, but ultimately they are disposed irregularly in the globule. It will be evident that the number of conidia in the head is variable, and not a significant character. They are united by some mucilaginous substance, but there is no excess of this substance between the conidia or round the whole mass. The head is a compact mass of spores without any visible hyaline outer coat. When the fungus is stained with methyl violet, the head stains violet, but the individual spores when separated are hyaline. The mucilaginous substance apparently takes the stain, but on the individual spore it forms such a thin layer that it does not produce any effect. It is soluble in water, and the spores separate when the fungus is mounted in water. In acetic acid the heads remain intact. The conidia are hyaline, narrow-oval or oblong-oval, ends rounded, 2·5–4 × 0·75–1·5μ.

Parkin recorded the occurrence of immature perithecia in one collection of *Cephalosporium Lecanii*. I have not met with perithecia in any recent gathering, and none now remain in Parkin's specimen. It is possible that they may have been perithecia of *Melanospora*.

The fungus grows well on maize-meal agar. On plating out in this medium minute white tufts are produced, each consisting of short hyphae radiating from a central point. These

suberect hyphae soon bear simple conidiophores laterally. On transferring to maize-meal agar slants, a pulvinate mass, 2–3 mm. in diameter, is produced at the point of inoculation, and thence the mycelium spreads over the surface of the slant in a thin film, somewhat tomentose with short projecting hyphae. The fungus is at first white, but in about fourteen days the colour changes to lemon-yellow from the pulvinate centre outwards. Fine strands extend over the glass from the edge of the slant. The agar becomes reddish, or yellowish-red, or orange-red.

The fungus was grown on Raulin's fluid, neutral Raulin (Guéguen), and Naegeli's solution, No. 3, with cane sugar, for comparison with the results of previous investigators.

In Erlenmeyer flasks of Raulin's fluid, the fungus produces minute white spheres up to 2 mm. diameter, the majority of which sink in a day or two to the bottom of the flask. A few may remain floating, and these attain a diameter of 3–4 mm., giving off hyphae which extend over the surface of the liquid and form groups of minute spheres surrounding the parent sphere at a short distance, but all these ultimately sink. The mycelium in this medium is stout, with numerous close-set, spherical or oval swellings. Conidiophores were not observed on the floating spheres; but where the latter adhered to the side of the flask, they formed stromata on the glass which bore conidiophores and conidia. Submerged spheres transferred to Raulin-maize-meal agar slants gave the same growth as that from inoculations with conidia of *Cephalosporium Lecanii* on that medium.

In flasks of neutral Raulin's fluid* white floating islands of mycelium were first produced. These became compact, convexo-pulvinate, up to 5 mm. diameter, and then began to coalesce with one another. After fourteen days the liquid was bordered by an almost complete ring of fused stromata, adherent to the glass, while those elsewhere had united into irregular bands, up to 1 cm. wide, convoluted, rounded above, and elevated in the middle up to 3 mm. above the surface of the liquid. These bands ultimately extended over the greater part of the surface, but they did not fuse into a continuous stroma, the intervening spaces being covered by a thin film of mycelium. The upper surface of these bands was then pale yellow and minutely tomentose; the lower surface became pale yellow, and then

* Neutral Raulin's fluid was prepared in accordance with the formula given by Guéguen in Bull. Soc. Myc. France, XIV (1898), p. 205, viz.:

Distilled water ...	1500 grams.	Magnesium sulphate	0·25 grams.
Cane sugar	70 ,,	Zinc sulphate ...	0·07 ,,
Neutral potass. tartrate	6·50 ,,	Iron sulphate ...	0·07 ,,
Ammonium nitrate ...	4·00 ,,	Potass. silicate ...	0·07 ,,
Ammonium phosphate	0·60 ,		

purple red to blood-red. The stromata at the edge of the liquid in contact with the glass adhered to the latter, as a rule, only by their edges, the remainder of the base being free and irregularly concave; on these the free part of the base was purple-red, and the margin in contact with the glass blood-red with a narrow yellow, external fringe. At the end of twelve weeks, the surface of the liquid was not covered by a continuous stroma.

In flasks of Naegeli's solution No. 3, with 5 per cent. cane sugar (Dop), similar minute floating islands of mycelium were produced. Some of these became 5 mm. in diameter, but the majority did not exceed 1–2 mm. The larger were feebly pulvinate. Hyphae spread out from these stromata over the surface of the liquid, uniting the whole by a very thin, transparent film. The stromata were at first white, finally pale yellow. The film did not thicken up to form a continuous opaque layer. At the end of twelve weeks the individual islets were still distinct, but they were united by a copious submerged weft of mycelium.

The flasks employed for the foregoing cultures were 7 cm. in diameter at the level of the liquid.

Tubes of Raulin agar did not solidify at Peradeniya. Growth on this medium resembled that in flasks of Raulin's fluid, minute white spheres being formed which sank into the medium. Some spheres which adhered to the side of the tube at the surface of the liquid formed minute white stromata which bore conidiophores and conidia. As the medium dried out, more spheres became adherent to the glass, and these ultimately became yellow, the reverse being pale purple-red or orange, with a yellow margin.

On slants of neutral Raulin agar the fungus made a limited growth. At the end of a fortnight a flattened-pulvinate, convoluted stroma had been formed, up to 2 cm. long, 1·5 cm. thick, and 3 mm. high, with a subvertical margin. A slight marginal growth, for a distance of 3–4 mm. over the surface of the agar, occurred later, but the convoluted stroma did not alter, and the fungus did not spread indefinitely over the medium. The colour of the stroma was at first white, becoming lemon-yellow. The reverse was deep orange-red, but the agar was not coloured.

On slants of Naegeli agar with cane sugar a small pulvinate stroma was formed at the point of inoculation, and thence the mycelium spread over the medium in a thin, pulverulent layer. Growth was poor, a patch about 2 × 1·5 cm. being produced in a month. This became pale yellow, with a broad, white, fimbriate margin, the reverse being orange-red, or orange-red in the centre with a yellow margin. The agar was not coloured.

On Dox's agar, with cane sugar and sodium nitrate, a circular, flat, rather compact patch was produced, slightly yellow in the

centre. The reverse was pale orange, becoming dull orange at the end of a month.

On all these media growth was evident to the naked eye in forty-eight hours. The cultures were held at room temperature, which during this period varied from 73° to 81° F. Conidia were produced in all cases, except on submerged growths. No yeasts were observed in any case.

Growth was more vigorous on sterilised potato than on sterilised carrot. On potato a thick, compact, white stroma was formed, covering the whole substratum and ultimately becoming lemon yellow and pulverulent. On carrot the fungus formed a loose, irregularly pulvinate stroma, which exhibited a tendency to grow out in processes, but extended over only half the area of the growth on potato; this ultimately became pale yellow.

Thus *Cephalosporium Lecanii* grows well on maize-meal agar and on neutral Raulin fluid with or without agar, though on the latter the growth is peculiarly limited, and thick, definite stromata are formed. On Naegeli agar the growth is poor, while on Raulin's fluid submerged growths are produced. The yellow colour of the fungus is more intense in culture than in nature.

On maize-meal agar the mycelium in the agar consists of stout hyphae, 3–4μ diameter, with thinner lateral branches down to 1μ diameter. The stout hyphae have walls up to 1μ thick, and bear frequent pyriform or oval swellings up to 6μ diameter (fig. 10). The swellings occur on one side of a septum, but not at all the septa. These hyphae are constricted at the septa. Lateral branches of these hyphae may be of the same character, or they may be regular, 2μ diameter, giving off finer branches 1μ diameter. These branches arise just below a septum, or from a swelling. All the mycelium is septate, the stouter hyphae more closely than the others. In young cultures the septa are 15–25μ apart; in old cultures the stroma consists chiefly of moniliform hyphae, with segments globose, 4–8μ diameter, or oval, up to 9 × 6μ. Abnormal conidiophores frequently arise from the terminal cell of a chain (fig. 11). In old cultures there appears to be a concentration of cell contents in some of the cells of the coarser hyphae; these cells have dense contents, while the other cells of the same hypha are empty.

B. *Hyalopus Yvonis* Dop.

Specimens of a fungus attacking *Aspidiotus perniciosus* on coconut leaves in Martinique were received by Dop in France and were described by him in 1905 under the name *Hyalopus Yvonis*. His description gives the mycelium as hyaline, not septate, repent, not very abundant, forming small grey patches:

the conidiophores erect, not septate, unbranched, terminated by a mucilaginous sphere containing conidia regularly arranged; the conidia hyaline, oblong, 4 × 1–1·5μ. The conidia multiplied by budding. I have not been able to ascertain whether a type specimen of this fungus exists.

Dop further stated that when the scale was detached from the leaf, it was found to be filled with hyphae and budding conidia (yeast cells), especially the latter. Some conidia were still enclosed in a mucilaginous sphere, but others were free, the sphere having been dissolved in the moist atmosphere in which the leaves were kept. Mycelium bearing the conidiophores radiated from the scales, but in the bodies of the dead insects he was unable to observe mycelium; they contained only the budding yeast cells. The latter were identical in shape with the conidia, but smaller. Dop considered that he had established, by cultures and infection experiments, that these yeast cells were a form of the *Hyalopus*.

Dop stated that pure cultures were readily obtained by passing a flamed needle lightly over the mycelium or under a scale. He cultivated the fungus on agar with Naegeli's solution plus 5 per cent. sugar, potato, bean agar, pumpkin agar, etc. Inoculations were made with conidia.

On agar with Naegeli's solution and sugar, the fungus, after eight to ten days, formed a smooth orange-yellow crust, which at first consisted entirely of budding yeast cells, identical with those observed in the body of the insect. When the medium began to be exhausted, short filaments appeared. The orange-red (*sic*) colour in these cultures was attributed to the presence of glucose.

Cultures on potato were similar to the foregoing.

In cultures on bean agar and pumpkin agar, neutral or acidified, growth was very slow and no pigment was produced. On peptonised media the development was still more feeble.

Good growth was obtained in a bouillon made by boiling specimens of *Aspidiotus nerii* in Naegeli's solution. The mycelial form developed very rapidly, and in eight to ten days the culture showed a strong development of interwoven hyphae, greyish in colour.

Dop specifically stated that in certain media (agar with glucose, potato), the fungus behaved as a yeast, while in other media (exhausted media, insect bouillon), it produced hyphae. He did not record that he transferred the yeast from potato to insect bouillon, and thereby converted it into a Hyphomycete, nor did he give any details concerning the source of his infection material in his various cultures. Further, he did not mention whether the hyphae in any of his cultures produced conidio-

phores and conidial spheres or not. It would seem not unfair to deduce that they did not.

Infection experiments were made by Dop on *Aspidiotus nerii*. These were successful only with the yeast form, that from cultures on potato being the most virulent. The fungus was inserted beneath the scale, and the inoculated insects were kept in a saturated atmosphere at a temperature of about 30° C. At the end of four or five days, the colour of the scale changed to brown and the insect died. In some places hyphae were produced, but conidiophores were not obtained.

The following would appear to be the probable interpretation of these results. Yeasts occur commonly in these insects, and an extensive literature relating to them is now available, dating back to 1854. Zimmermann (1901) observed them in *Lecanium viride*, and from his account it would appear that he found them universally in that insect. If material for inoculation was obtained by passing a needle under a scale, it is most probable that a culture of one of these yeasts would result.

Again, it is very difficult to secure pure cultures of one of these scale insect Hyphomycetes by simply touching the conidiophores with a needle. As the conidiophores in this case are only about 20μ high, the margin of safety is very small. The repent mycelium entangles spores of numerous leaf-inhabiting fungi, in addition to spores of common moulds and species which grow on dead scales; and if that is touched contamination is almost inevitable. Plating is essential in order to separate the insect fungus from *Pestalozzia, Cladosporium, Fusarium,* etc., especially as these grow more rapidly than the former.

It would seem probable from Dop's account that the grey mycelium obtained in culture was that of a *Cladosporium*. In any case there is no evidence that it belonged to the *Hyalopus*. The hyphae which developed from the scales which died after inoculation with the yeast may have arisen from any chance fungus spores which happened to have lodged round the insects. Scale insects usually die when kept in a saturated atmosphere in a closed glass dish.

While Dop's article was in the press Guéguen published his account of *Acrostalagmus coccidicola*. Dop stated that the latter species differed from *Hyalopus Yvonis* in its colour, its branched conidiophores, and the absence of budding in the conidia. His conclusions with regard to the last point were doubtless founded on erroneous observations. There would appear to be scarcely any room for doubt that *Hyalopus Yvonis* is morphologically identical with *Cephalosporium Lecanii*.

C. *Cephalosporium* (*Acrostalagmus*) *coccidicolum* Guéguen

In 1904 Guéguen described, under the name *Acrostalagmus coccidicola*, a fungus which he had found on a coccid on the leaves of a shrub (? *Mikania*). The mycelium formed a film, egg-yellow in colour, round the body of the insect and extended in radiating hyphae over the surface of the leaf. A translation of his description of the fungus is as follows:

Mycelium floccose, anastomosing, white, then egg-yellow, sparingly septate, 3μ diameter. Fertile hyphae caespitose, erect, scarcely exceeding 3μ in diameter, cylindric, attenuated at the apex, sparingly septate; lateral branches scattered, simple, acute, subsolitary, alternate, or subternate. Conidia cylindric, with rounded ends, hyaline, smooth, mucilaginous, pale yellow, 4–5 × 1μ, forming a spherical globule which soon collapses.

I am informed that no type specimen of this species exists.

Guéguen cultivated the fungus on Raulin's fluid, potato, and carrot, the cultures being held at room temperature, 15 to 18° C. On Raulin's fluid, at the end of a week, a thick, densely-felted crust was formed, yellowish white and farinaceous-fibrillose above, bright yellow and woolly below; the mycelium was so compact that the tubes and flasks containing the cultures could be turned upside down without spilling the liquid.

On potato isolated tufts were formed, velvety and creamy white. On carrot the fungus grew more rapidly, and the mycelium extended over the surface in a large, yellow, velvety band, bearing abundant conidia in the centre, and bordered by a delicately cottony, pure white cushion; the colour finally became sulphur-yellow or lemon-yellow.

Guéguen remarked that in all the cultures the colour of the fungus was paler than in nature, the natural colour being gamboge-yellow or egg-yellow. He attempted to infect an undetermined coccid on Oleander by applying the spores to the insect with a brush, but without success.

Guéguen's small-scale figure shows an apparent conidiophore, with lateral branches, opposite, or solitary and scattered. This is similar to what first appears in plate cultures of *Cephalosporium Lecanii*, and it is probably only a hypha with simple lateral conidiophores. Under natural conditions these hyphae are repent on the leaf, but in the saturated atmosphere of a Petri dish they stand suberect. Guéguen's figure on a larger scale is apparently a conidiophore from a culture.

Guéguen obtained his fungus from a shrub, which it was suggested was a *Mikania*, in a greenhouse at the Paris Exhibition of 1900. The origin of the shrub was not recorded, but if the suggested identification was correct, it may have come from America.

According to the description *Acrostalagmus coccidicola* does not differ morphologically from *Cephalosporium Lecanii*; but biologically it differs in its growth on Raulin's fluid, its more luxuriant growth on carrot than on potato, and its paler colour in culture than in nature.

Dr C. Spegazzini has kindly forwarded me a specimen of a *Cephalosporium* on *Pulvinaria* sp. on *Citrus deliciosa* from La Plata; and cultures of this have been obtained at Peradeniya. The fungus does not differ appreciably from *Cephalosporium Lecanii* in morphological characters. It has compound, as well as simple conidiophores, and on the former can be assigned to *Acrostalagmus*.

On maize-meal agar the growth of the Argentine species is more fluffy than that of *Cephalosporium Lecanii*; it remains white longer, becomes only pale yellow, and does not colour the agar. The reverse is yellow, becoming olive here and there.

In flasks of Naegeli solution, or on slants of Naegeli agar, the behaviour of the Argentine form was similar to that of *Cephalosporium Lecanii*, except that, on the slants, the colour of the upper surface of the stroma was paler.

In flasks of neutral Raulin solution growth was again similar to that of *Cephalosporium Lecanii*, the same irregular convoluted bands being formed. The reverse of these stromata was, however, yellow at first, ultimately becoming olive.

On slants of neutral Raulin agar, a limited cushiony stroma was produced at first, but further growth occurred until almost the whole slant was covered. The stroma became yellow and exuded drops of a brown liquid. The reverse was yellow at first, but became olive, and the agar was coloured a muddy brown.

In flasks of Raulin solution growth was even better than on neutral Raulin. Of the same character at first, growth continued until the surface of the liquid was covered by an irregularly pulvinate layer, with a broad, thick, irregularly pulvinate border extending along the glass. The colour remained white or very pale yellow, the reverse being yellow to olive.

On slants of Raulin agar the growth was again vigorous, covering the medium with a thick cushiony stroma, sporiferous in a band down the middle, with stout swollen margins. The colour of the stroma was yellow, the reverse being yellow, then olive, and finally yellow-brown, while the agar was coloured yellow-brown.

On Dox's agar growth was similar to that of *Cephalosporium Lecanii*, the stroma being rather more deeply coloured pale yellow above. The reverse was pale yellow, becoming yellow to greenish-yellow at the end of a month.

On both sterilised potato and sterilised carrot the growth was thick and cushiony, and ultimately pale yellow. Growth on potato was better than on carrot, the mycelium in the former case spreading from the potato over the sides of the tube.

Thus the Argentine fungus differs from *Cephalosporium Lecanii* in its luxuriant growth on Raulin's fluid, the different colour of the reverse of the culture on neutral Raulin's fluid or neutral Raulin agar, the coloration of neutral Raulin agar, and the lack of coloration of maize-meal agar. It is usually of slower growth at first than *Cephalosporium Lecanii*, the mycelium not being visible until the fourth day.

On the other hand, the Argentine fungus agrees with Guéguen's account of *Acrostalagmus coccidicola* in its growth on Raulin's fluid, the initial colour of the reverse on that medium, and its paler colour in culture than in nature. It differs in that the growth on carrot is not better than the growth on potato, as far as regards Ceylon samples of these vegetables.

On the whole, it would appear that the Argentine fungus is the same as *Acrostalagmus coccidicola*; and that while this species does not differ from *Cephalosporium Lecanii* morphologically, it does differ biologically.

The question arises whether these species should be referred to *Hyalopus*, *Cephalosporium*, or *Acrostalagmus*. Guéguen, in his paper on *Acrostalagmus Vilmorinii*, described that species as producing simple, as well as branched, conidiophores, and stated that the varied form of its conidiophores gave him cause for hesitation in classifying it generically. He noted that the genus *Hyalopus* differed from *Acrostalagmus* only in its simple conidiophores, and that Parkin and others had placed in *Cephalosporium* species which did not differ from *Hyalopus*.

Guéguen considered that the difference between *Acrostalagmus* and *Hyalopus*, *i.e.* "the more or less regular arrangement of the conidiophores round the axis which supports them," was not sufficient to maintain the two distinct. His *Acrostalagmus coccidicola* frequently produced, especially in the early stages of a culture, simple conidiophores corresponding to *Hyalopus*, and he considered that it was probably these which Dop had described as *Hyalopus Yvonis*, a species which appeared to be identical with *Acrostalagmus coccidicola*.

Guéguen concluded that the genus *Hyalopus*, and possibly also the genus *Cephalosporium*, should be discarded, their several species being placed in *Acrostalagmus* if their conidia were mucilaginous, or in *Stachylidium* if their conidia were pulverulent.

Guéguen's statement regarding the difference between *Acrostalagmus* and *Hyalopus* was probably based on observations on

the repent hyphae, bearing scattered simple conidiophores, which become suberect in culture, and mimic compound conidiophores. The difference really is between the simple conidiophores of *Hyalopus*, and the compound, regularly branched conidiophores of *Acrostalagmus*. The fact that both forms may occur in some species would not necessarily be a sufficient reason for combining the two genera.

Parkin noted that *Cephalosporium Lecanii* had mucilaginous conidial heads, and on that character should rather be referred to *Hyalopus*. *Hyalopus*, however, is supposed to have heads which consist of a large globule of mucilage, in which the spores float free from one another for the greater part. In *Cephalosporium Lecanii*, as already stated, no such excess of mucilage has been observed.

Lindau, discussing *Hyalopus Populi*, stated that in culture in a damp atmosphere it produced spherical heads in which the conidia were bound together by mucilage, but in a dry atmosphere the conidiophores bore only separate conidia united loosely into a head. In the latter case, the fungus did not differ in the slightest degree from *Cephalosporium*, and hence he was of opinion that *Hyalopus* was only a *Cephalosporium* grown under moist conditions.

Buchanan discussed the relationship of *Hyalopus* and *Cephalosporium* in a paper on *Cephalosporium Pammelii*. He found that the spores of that species were mucilaginous, but in a dry atmosphere only sufficient mucilage was produced to cause the spores to adhere to one another. In a moist atmosphere the globule of mucus swelled until its volume was three to four times that of the mass of spores, and the individual spores floated free in the liquid. Consequently, he agreed with Lindau that *Hyalopus* should be merged in *Cephalosporium*.

The fungus studied by Buchanan ultimately formed septate conidia. Hence it would appear that it was similar to the conidial stage of certain species of *Nectria*, in which first a *Cephalosporium* and then a *Fusarium* is produced. In hanging-drop cultures of such species, *e.g. Nectria haematococca*, the *Cephalosporium* spores may frequently be found floating free in a drop of liquid at the apex of the conidiophore, though I have only observed this when the drop was in contact with the cover-glass.

There is thus general agreement that *Hyalopus* should be merged in *Cephalosporium*. The two genera appear to have been instituted at the same time, *Hyalopus* having page priority. But the name *Cephalosporium* has been more generally adopted, and for that reason should be retained.

Acrostalagmus differs from *Cephalosporium* in having branched,

instead of simple, conidiophores. The separation would appear to be a convenient one as far as perhaps the majority of species of *Cephalosporium* are concerned, though there undoubtedly are species which have both simple and branched conidiophores. *Acrostalagmus* is prior to *Cephalosporium*.

As regards the scale insect species, these have both simple and branched conidiophores. But most of the conidiophores are simple, and there would be no advantage in placing them in *Acrostalagmus*, where they would seldom be looked for. Perhaps the simplest course is to leave them as *Cephalosporium* (*Acrostalagmus*) *Lecanii*, and *Cephalosporium* (*Acrostalagmus*) *coccidicolum* respectively. If biological species are not admitted the former name has priority.

D. *Cephalosporium* (*Acrostalagmus*) *longisporum* Petch.

In 1916 a *Cephalosporium* was found in Ceylon on *Icerya purchasi*, the fluted scale, which had recently been introduced into the island. It was recorded at the time as *Cephalosporium Lecanii*, but it has larger conidia than that species. It occurred alone, or in company with a *Melanospora*.

The fungus spreads from the insect over the surrounding bark, and forms a border round it up to 3 mm. wide, at first white, then sulphur-yellow. It also overruns the insect and turns it yellow, but it is difficult to detect among the curled waxy filaments which cover the insect, and the latter appear to become yellow, in part, naturally, independently of any fungus attack.

The yellow border is byssoid, more coarsely fibrillose than that of *Cephalosporium Lecanii*, and usually radially ridged, the ridges broadening slightly towards the outer edge and terminating in a thick brush of hyphae. These ridges are covered with short erect conidiophores, bearing globose heads of conidia.

The mycelium is about 2μ diameter, hyaline and septate. The simple conidiophores are up to 24μ high, usually 1–1·5μ diameter at the base, tapering uniformly to the apex, but sometimes shorter, 12μ high, 2·5μ diameter at the base, tapering regularly to about two-thirds their height and thence continued as a thin sterigma. They may be straight or curved.

With these occur branched conidiophores, with a stem 1·5μ diameter, bearing one or two whorls of branches. The branches are up to 12μ long, elongated flask-shaped, 1·5μ diameter below, tapering uniformly to about 8μ and terminating in a fine point about 4μ long. In some cases the branches may be inflated to 2μ at the base and consequently appear more flask-shaped.

The heads of conidia are up to 30μ diameter, but generally smaller, up to 16μ. The conidia are oblong-oval, sometimes

attenuated to one end, or subclavate, with one end sometimes subacute, 6–12 × 1·5–2·5μ.

The insect occurs principally on *Acacia decurrens* in the hill districts of Ceylon. In January, 1924, specimens of the fungus being required for cultivation, the plant collector was sent up to Hakgala with instructions to collect twigs of *Acacia* bearing yellow specimens of the insect. In this he was unsuccessful, but brought down living examples of the insect on *Acacia decurrens*. These on receipt (January 8th) were placed in a large glass dish with a loosely-fitting cover. The young insects, about 0·6–1 mm. long, very soon deserted the old insects and the *Acacia* branches and congregated in hundreds on the side of the dish facing the light. On January 16th it was noticed that nearly all these young insects were attacked by a fungus, and on examination this proved to be the large-spored *Cephalosporium*.

The fungus on these young insects, and in the saturated atmosphere of the glass dish, formed loose, whitish tufts of hyaline hyphae. These hyphae bore simple conidiophores, up to 24μ high, and, in addition, tall *Acrostalagmus* conidiophores. The latter were up to 110μ high, 2μ diameter at the base, septate, usually with two whorls, each of three branches, the one near the apex making, with the terminal segment of the main axis, a group of four branches. The branches were usually long, up to 30μ, 1·5μ diameter below, tapering uniformly to the apex. In one instance a conidiophore forked below into two branched conidiophores, the total height of the whole being 180μ. Irregular conidiophores were not uncommon. One, 70μ high, had a pair of opposite branches at a height of 30μ and a single branch at 50μ. Another conidiophore had a whorl of three branches, of which one was 30μ long, and the other two about 8μ long.

The heads of conidia on the branches of the larger conidiophores are usually small, ovoid, 8–10μ diameter, and the conidia are arranged in them in a parallel bundle, side by side, not irregularly as in the larger heads on the simple conidiophores.

On maize-meal agar the fungus forms at first a flat white circular stroma, narrowly concentrically zoned. The heads of conidia are large and consequently the stroma presents a "crystallised" appearance instead of the powdery appearance of *Cephalosporium Lecanii*. After a few weeks the central part develops white tufts of mycelium and becomes thicker and woolly, though still remaining flat; and finally the stroma becomes pale yellow from the centre outwards. The agar is slightly reddened.

On Dox agar growth is limited, a compact convoluted stroma being formed, pale yellow to white in colour. The reverse is orange and the agar is not coloured.

On Naegeli agar growth is equally limited, the stroma being flat, slightly woolly tomentose, pale yellow in the centre, with a white margin. The reverse is orange-yellow, becoming yellow-brown, and the agar is not coloured.

On neutral Raulin agar a thick, convoluted stroma is formed, larger and thicker than on the two previous media, but much less extensive than on maize-meal agar. It becomes sulphur-yellow, more deeply coloured than on the other media, with a white margin, and with the reverse yellow to orange-yellow. The agar is not coloured.

Apparently the same species has been collected on an aphis at Peradeniya. In these specimens the fungus covers the body of the insect and spreads out in rather coarse strands along the legs and over the leaf. The central part of the stroma is ultimately covered with pale yellow masses of conidia, which may fuse into a continuous waxy sheet, while the spreading mycelium in the available specimens is white. Both simple and compound conidiophores are present, the former 16–32μ high, 1–2μ diameter at the base, and the latter up to 36μ high, 2μ diameter below, with a single whorl of branches. The conidia measure 6–10 × 1·5–2μ. As the only available specimens were collected ten years ago, it has not been possible to run parallel cultures of this form on *Aphis*. Consequently, it may not be biologically equivalent to the fungus on *Icerya*. Morphologically, however, the two are identical.

As already stated, a *Melanospora* occurs on *Icerya purchasi* on *Acacia decurrens* in Ceylon. Whenever the insects are found to be attacked by *Cephalosporium longisporum*, a large percentage, usually 50 per cent. or more, bear the *Melanospora*, in addition to the *Cephalosporium*. In a few cases the insect appears to bear the *Melanospora* only, *Cephalosporium* conidiophores not being evident; but these insects are covered with yellow mycelium which is probably that of the *Cephalosporium*.

The *Melanospora* agrees in all details with *Melanospora parasitica* Tul. The basal part of the perithecium is reddish-brown, spherical, 0·15–0·2 mm. diameter, with a cylindrical ostiolum, up to 1 mm. high, 50μ diameter below, tapering to 20μ diameter above, blackish-brown below, becoming paler above. The spores are cylindric, with truncate ends, becoming more barrel-shaped in culture media, 5–8 × 2–2·5μ. The weft of mycelium at the base of the perithecium is composed of regular, distinctly septate hyphae, 3μ diameter, with a rather stout wall which appears yellowish under a high magnification.

De Bary stated that *Melanospora parasitica* had a conidial stage consisting of short, verticillately-branched hyphae, with whorls of secondary branches from which the conidia were

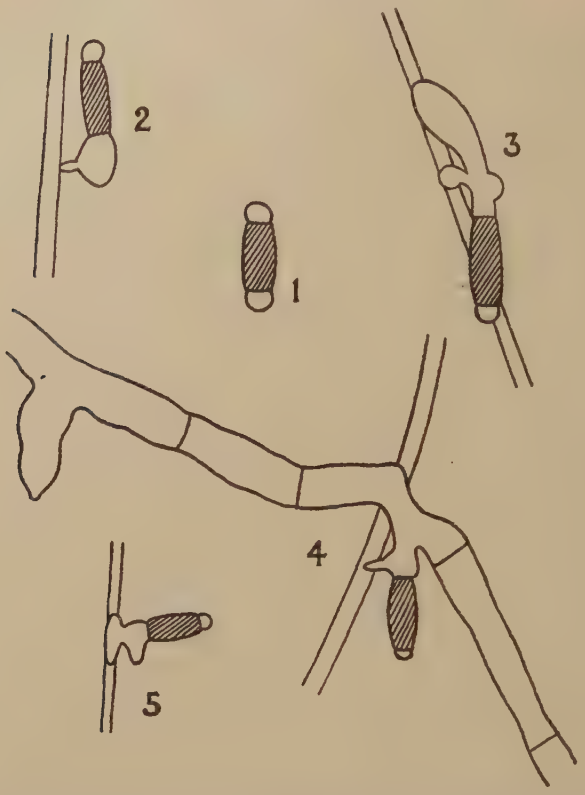
abjointed acrogenously and serially, but that it was very rarely produced. Nothing of that description has been observed in the present investigations, except *Spicaria javanica,* which shows no evidence of being related to *Melanospora.* Berlese found that *Melanospora globosa,* described from specimens on decaying herbaceous plants and fragments of wood, had an *Acrostalagmus* conidial stage, which he considered to be *Acrostalagmus albus* Preuss. Consequently, it is of interest to determine whether the *Cephalosporium* (*Acrostalagmus*) found on *Icerya* is related to the *Melanospora* which so generally accompanies it.

Cultures on maize-meal agar started with *Cephalosporium* conidia do not produce *Melanospora* perithecia. That is the case, whether single spore colonies are transferred to maize-meal tubes, or whether several colonies are allowed to grow on the same plate until they meet.

The spores of *Melanospora* are extruded when mature and form first a globule and then a powdery mass at the apex of the ostiolum. Spores taken from the ostiola of perithecia on the insect, which had been extruded for some days, did not germinate in hanging drops or films of water, maize-meal agar, or Dox agar, in damp cells. Spores taken from the ostiola of perithecia in culture, when first extruded and in a globule, germinated in similar maize-meal agar films; but others taken from the same culture, after the masses of spores had become powdery, did not germinate under the same treatment. When, however, the film in the latter case was allowed to dry, and re-wetted twenty-four hours later, some of the spores germinated. In all cases, the spores produced a hemispherical, or subglobose, hyaline protuberance at each end, but no further growth resulted. When two spores happened to lie with their ends almost in contact, their hyaline protuberances fused with one another.

When spores of *Melanospora* were plated on Dox agar or maize-meal agar, no growth was visible to the naked eye.

Cephalosporium spores and *Melanospora* spores were sown on opposite sides of maize-meal agar films in damp cells. The *Melanospora* spores, obtained from culture, germinated, while the *Cephalosporium* mycelium quickly overran the film. When a *Melanospora* spore was situated near a *Cephalosporium* hypha its hemispherical "germ tube" enlarged, becoming irregularly oval, and put out laterally a slender conical haustorium which attached itself to the hypha. A stout irregular mycelium, 3–4μ diameter, then developed from the enlarged germ tube and ran through the culture, giving off here and there lateral subglobose protuberances which attached themselves to the *Cephalosporium* hyphae. *Melanospora* perithecia were subsequently produced on the films.



Melanospora parasitica Tul. 1, germinating spore; 2, haustorium attacking a *Cephalosporium* hypha; 3, early stage of development of the *Melanospora* mycelium; 4, later stage of the same; 5, expansion of a haustorium within a *Cephalosporium* hypha; all × 1500.

Melanospora perithecia may be obtained in quantity by plating together the conidia of the *Cephalosporium* and the ascospores of the *Melanospora*. The *Cephalosporium* develops first and produces normal zoned colonies, the *Melanospora* perithecia appearing in about ten days. The first *Melanospora* spores from culture used in the foregoing germination tests were obtained accidentally in that way. The hyphae of the *Cephalosporium* ascend the ostiola of the *Melanospora* and produce conidia anywhere along its length. Consequently, in plating *Melanospora* spores from the insect, the *Cephalosporium* may occur as a contamination, and hence the culture produces perithecia later. After repeated transfers on maize-meal agar, the *Melanospora* covers the mixed culture with white mycelium, and the perithecia do not appear until the culture is about a month old.

The foregoing results are in accordance with those obtained by Kihlman with *Melanospora parasitica*, as cited by de Bary and others. I have not been able to consult the original paper. Kihlman found that the *Melanospora* spore germinated by the emission of a germ tube at each extremity, the tubes, whether grown in water or in nutrient solution, being scarcely longer than the transverse diameter of the spore. If the spore was lying against, or on, a hypha of *Isaria*, the germ tube became firmly attached to the hypha of the host and then developed into a mycelium, while if the germ tube came in contact with an older hypha of *Melanospora*, the membrane between them was dissolved and they coalesced with one another.

Zopf described and figured the haustoria of *Melanospora Didymariae*, attacking the paraphyses of *Humaria carneo-sanguinea*, on which it is parasitic.

The precise nature of the attachment of the haustoria of *Melanospora parasitica* to the hyphae of its host fungus does not appear to have been ascertained. The observations made in the present experiments indicate that the haustoria formed by the hyphae in general are different from that formed by the germ tube. The former are subglobose, and are attached to the host hypha over a wide base, or may partly encircle it. The latter is slender, conical, and terminates in a point which is attached to the host hypha, as in the case figured by Zopf.

In one instance after staining with eosin it appeared that the haustorium had penetrated the wall of the host hyphae, and had formed an irregular vesicle inside it, but it has not been possible to carry out further investigations to confirm this.

It is clear from the observations recorded that *Melanospora parasitica* is strictly parasitic on fungi, and in the present case it is parasitic on the *Cephalosporium*, not on the insect.

Cephalosporium longisporum n.sp. Mycelium sulphur-yellow, encircling the host insect with a byssoid, fibrillose stroma up to 3 mm. wide. Hyphae 2μ diameter, hyaline, regular, septate. Conidiophores simple, 24μ high, 1·5μ diameter, attenuated upwards, or branched, up to 110μ high, bearing elongated flask-shaped branches, up to 30μ long, in whorls of three. Conidial heads globose, up to 30μ diameter, or ovoid, 8–10μ diameter. Conidia hyaline, oblong-oval or subclavate, sometimes subacute at one end, 6–12 × 1·5–2·5μ. On *Icerya purchasi*, Ceylon.

E. *Cephalosporium* (*Acrostalagmus*) *coccorum* Petch.

In September, 1920, I collected an *Acrostalagmus* at Hedon and at Aldborough, East Yorkshire, in both cases on *Chionaspis salicis* on Ash. Apparently the same species was again collected on *Lepidosaphes ulmi* on Hawthorn at Hunstanton, Norfolk, on

several occasions from October, 1920, to February, 1921; while Mr E. E. Green sent me specimens from Camberley in November, 1920, on *Lepidosaphes* on Apple.

On *Lepidosaphes* the fungus grows out from beneath the scale and forms a minute, white, rather loose, byssoid patch over the adjoining bark. It may also extend in a thin film over the scale. In the available specimens, it does not form a complete border round the scale, nor does it spread far over the host plant. The patch is minute and inconspicuous.

On *Chionaspis* the fungus similarly grows out in minute tufts from the margin of the scale, but some hyphae, in the specimens collected, run more generally over the whole colony. Consequently, when the conidiophores are developed, extensive patches are covered with a delicate bloom. There is not, however, a conspicuous film of hyphae over these patches.

The hyphae are about 2μ diameter, hyaline, septate. They bear either simple or branched conidiophores. The simple conidiophores (fig. 12) are 12–25μ high, 1·2–2μ diameter at the base, tapering uniformly to the apex, or tapering uniformly to about 6μ from the apex and thence continued as a thin sterigma. They are generally continuous, but may have a transverse septum in the lower half. Each conidiophore bears a spherical head of spores, generally small and from 4 to 10μ in diameter, but these may coalesce into spheres 12–16μ diameter. The conidia are hyaline, narrow-oval or oblong-oval, usually with one end subacute, 3–5 × 0·75–1·5μ, sometimes 6·5 × 2μ, generally straight, but sometimes slightly curved (fig. 15).

The branched conidiophores (figs. 13, 14) are up to 120μ high. Some are short with only a single pair of branches. Others, up to 90μ high, have a single whorl of branches in the upper third. The larger have two whorls of branches in the upper half of the conidiophore, with three or four branches in a whorl. The branches are usually 14–16μ long, but on the larger conidiophores they may attain a length of 30μ; they are up to 2μ diameter at the base, and taper uniformly to the tip, but are frequently slightly contracted and rounded at the point of attachment and consequently appear more flask-shaped than the simple conidiophores. The stalk of the conidiophore is septate, and 2μ diameter, or in the larger examples 3μ diameter, at the base.

The globose heads of conidia do not long remain attached to the apices of the branches of the conidiophores. They frequently slip down and form a continuous mass round the main stem in the axils of the branches.

In general structure this species resembles *Cephalosporium Lecanii*. In the latter the simple conidiophores are sometimes

flask-shaped, but in general they are uniformly tapering, as in this species. The spores of the British species are slightly narrower than in *Cephalosporium Lecanii*, and occasionally a few spores occur which are longer (6·5μ) than those usually found in *Cephalosporium Lecanii*.

The principal differences between this species and *Cephalosporium Lecanii* are the colour of the fungus, its mode of growth, and the abundance of comparatively tall *Acrostalagmus* conidiophores. The latter is a very marked feature in comparison with the scarcity and small stature of the branched conidiophores of *Cephalosporium Lecanii*. The "bloom" observable on a colony of *Chionaspis* attacked by this fungus is chiefly due to the presence of numbers of erect conidiophores.

Cephalosporium Lecanii forms a definite conspicuous patch round the scale, and finally covers it with a continuous compact stroma. In the present species only small tufts, or loose byssoid patches, are formed, and the fungus is scarcely visible, especially on *Lepidosaphes*, until the insect is examined with a lens. It might be supposed that this meagre growth is attributable to the lower temperature to which the English fungus is subject, but on the other hand the actual conidiophores are larger than those of *Cephalosporium Lecanii*. *Cephalosporium Lecanii* is at first white, and later becomes yellow. The British species is apparently permanently white. This may perhaps be related to the looser habit of the mycelium; loose growths of *C. Lecanii* are permanently white.

It has unfortunately not been possible to run parallel cultures of this species and *Cephalosporium Lecanii*. Specimens of the former, collected in February, 1921, were brought out to Ceylon in April, but by the time the matter could be taken up the conidia proved to be dead.

I was unable to find any species resembling this under *Cephalosporium*, *Acrostalagmus* or *Verticillium* in Herb. Kew or Herb. British Museum. Corda described and figured *Verticillium minutissimum*, on a very small insect larva, but neither his description nor his figure agrees with the present species.

In 1882 Penzig recorded an *Acrostalagmus* on *Lecanium hesperidum* on lemon in Italy. He stated that the fungus covered the part of the leaf on which the dried body of a *Lecanium* was situated, with a white film. From his figures, which were reproduced in Saccardo, *Fungi Italici*, No. 1194, it would appear that the fungus surrounded the insect in a white, loose and somewhat floccose border, 1–1·5 mm. wide. The conidiophore, as shown in the figure, is erect, with five successive whorls of branches, and up to six branches in a whorl. The branches are long and tapering, and in one instance again

branched. Penzig assigned this species to *Acrostalagmus albus* Preuss, though he noted that there were some slight differences from the original description of the latter. He stated that it often occurred in company with *Verticillium heterocladum*.

Acrostalagmus albus was described by Preuss in *Linnaea*, XXIV (1851), p. 126. The following is the original description, for which I am indebted to the Imperial Bureau of Mycology:

"Caespitibus effusis, tenuibus, sublanuginosis, albis; hyphopodio ramoso, repente, septato; stipite erecto, pellucido, aspero, supra ramuloso; ramulis continuis, verticillatis, ternatis vel sexternis, apice capituliformibus; globulis sporarum globosis albis; sporis numerosissimis minutis ovatis albis. Habitat in ligno nigrescente *Alni glutinosae*. Hoyerswerda."

The description given in Saccardo, *Sylloge Fungorum*, IV, p. 163, is apparently one drawn up by Penzig in 1882. It reads as follows:

"Caespitulis effusis, tenuibus, sublanuginosis, albis; hyphis sterilibus repentibus, continuis v. spurie septatis, paullum ramosis, ramos fertiles 200–220 × 1·7–2 emittentibus; ramis fertilibus ascendentibus v. repentibus, supra ramulosis; ramulis continuis, verticillatis, ternis vel senis, interdum solitariis, alternis, paullum curvatis, apice attenuatis, summa extremitate capitulum gerentibus; capitulis sphaericis, tenuissimis, columella carentibus, caducis, 9–10μ diam., conidia numerosissima foventibus; conidiis minimis, elliptico-oblongis, 3·3–3·4 × 1–1·5μ hyalinis. Hab. in ligno Alni glutinosae Hoyerswerda et in foliis Citri Limonum *Lecanio Hesperidum* infectis in Italia boreali."

Penzig's description and figures do not agree with *Cephalosporium Lecanii*, in which the *Acrostalagmus* form is poorly developed in nature. They do, however, agree with the species collected on *Lepidosaphes* in England, though the mycelium is more abundant and the conidiophores larger. It is to be noted that the conidiophores were either erect or creeping, and that the branches were in whorls or solitary. It is probable that the repent conidiophores were repent hyphae, bearing simple conidiophores. Penzig's fungus would appear to be the same as the English species on *Lepidosaphes*, etc.

On the other hand, it does not appear likely that Penzig's specimen was correctly assigned to *Acrostalagmus albus*. The description of the latter is little more than generic, but the fact that the stalk was rough excludes the scale insect species. Moreover, the habitat, on blackening wood, is opposed to the view that the type of *Acrostalagmus albus* was on a scale insect which the describer overlooked. It is not usual to find scale insects on decaying wood. In all probability *Acrostalagmus albus* is a saprophytic lignicolous species, not an entomogenous species.

Berlese regarded *Acrostalagmus albus* as the conidial stage of *Melanospora globosa*, a saprophytic species.

In the *Gardeners' Chronicle*, LVII (1915), p. 139, Horne described *Cephalosporium Lefroyi* on *Aleurodes vaporariorum*, found on *Centropogon* at Wisley. Specimens of this are not now available. The conidiophores were simple, septate or continuous, fastigiate, with a globose head ± 3·5–7μ diameter. The conidia were hyaline, ellipsoid, ovoid, or oblong, straight or slightly curved, ± 7 × 1–1·7μ. The hyphae were septate, 1·7–3μ diameter, and the fungus white. The dimensions given for the conidia are larger than those of the species on *Lepidosaphes*, though they would fit exceptional spores of the latter. But no mention is made of branched conidiophores in *Cephalosporium Lefroyi*, whereas these are a conspicuous feature in the *Cephalosporium* on *Lepidosaphes* and *Chionaspis*. Moreover, Horne stated that the mode of occurrence of the *Cephalosporium* on the *Aleyrodes* nymph agreed in every respect with Parkin's description and figure of *Cephalosporium Lecanii* on *Lecanium*, which is decidedly not the case in the present species. From these details and the dimensions of the spores, it would appear that the latter species is not the same as *Cephalosporium Lefroyi*. Accordingly, I propose the name *Cephalosporium* (*Acrostalagmus*) *coccorum* for it.

Cephalosporium* (*Acrostalagmus*) *coccorum n.sp. Mycelium septate, regular, hyaline, 2μ diameter, forming minute white patches at the side of the scale, or a thin film over it; conidiophores simple, 12–25μ high, 1·2–2μ diameter at the base, tapering upwards uniformly, continuous or septate; or compound up to 120μ high, 2–3μ diameter, septate, bearing tapering branches, 14–30μ long, 2μ diameter, in whorls of three or four; conidial heads globose, 4–10μ diameter; conidia hyaline, narrow-oval or oblong-oval, usually with one end subacute, usually straight, sometimes slightly curved, 3–5 × 0·75–1·5μ, rarely 6·5 × 2μ. On *Lepidosaphes ulmi* and *Chionaspis salicis*, England.

F. *Spicaria javanica* Bally.

In July, 1922, specimens of a *Ceroplastes* on *Santalum album*, which were attacked by *Cephalosporium Lecanii*, were collected in the Botanic Gardens, Peradeniya. An attempt was made to start a culture of the *Cephalosporium* by transferring spores directly from the insect by means of a platinum needle. The tubes inoculated proved in all cases to contain fungi other than the *Cephalosporium*, *e.g. Cladosporium*, *Pestalozzia* and *Spicaria*. Examination of the scale insects showed that the *Spicaria* occurred on them, intermingled with the *Cephalosporium*. The

same *Spicaria* has also been obtained on plating out *Cephalosporium* spores from *Lecanium viride* and *Icerya purchasi*, and it has been found on *Lecanium viride*, on caterpillars of *Euproctis flava*, and on egg masses of *Homona coffearia*. On *Lecanium viride* it occurred when scales attacked by *Cephalosporium Lecanii* were kept in a closed glass dish, forming minute, pulverulent, violet-grey tufts. On the caterpillars of *Euproctis* it formed loose white masses, covering the insect and spreading over the leaf; these masses remained permanently white, but in culture the same violet-grey colour was produced as in the *Spicaria* from *Lecanium*, *Icerya* and *Ceroplastes*.

It may have been this fungus, or that next described, of which Parkin saw the conidia in chains when specimens of *Lecanium* attacked by *Cephalosporium Lecanii* were kept in a damp chamber. Cultures show that it is not related to the *Cephalosporium*.

On maize-meal agar (in tube culture) this *Spicaria* forms small pulvinate masses, which are united at first by a rather scanty growth of mycelium. Numerous erect delicate conidiophores are produced, which tend to be aggregated in small tufts. As growth proceeds a thick continuous layer is formed, consisting chiefly of masses of conidia, the surface being irregularly nodular. The reverse now shows a continuous felted layer of mycelium, irregularly wrinkled, at first pale yellow in colour, becoming ochraceous. This mycelium lies chiefly in the agar. The mass of spores is white at first, but ultimately becomes violet-grey. When the culture is old, the growth collapses into an even stratum consisting principally of spores.

The margin of the culture, along the edge of the slant, is white and fimbriate. As the culture ages hyphae grow out from the margin over the surface of the glass in white strands up to 0·2 mm. broad, which divide and anastomose. These extend over the glass until the strands from the two sides meet. Conidiophores are produced along these strands.

In some tubes erect white clavae, up to 1·3 cm. high, and 1 mm. diameter below, arise from the surface of the culture, usually in the lower half, when it is old.

On neutral Raulin agar growth is more vigorous than on maize-meal agar; the slant is soon covered with violet-grey masses of conidia, and within three weeks there is a copious growth of strands of mycelium over the sides of the tube; the colour of the reverse is orange to orange-red. On Raulin agar the growth is good, but strands do not appear so early as in the previous case, and the reverse is yellow to orange-yellow. On Naegeli agar with cane sugar the growth is poor; the reverse of the culture is pale orange.

On gelatine the reverse is yellow to orange-yellow. The gelatine is not liquefied.

On Dox agar the reverse is orange. The agar is not coloured.

On sterilised potato growth is good, the substratum being covered with violet-grey masses in a week. Growth on sterilised carrot is slower.

The colour of the masses of conidia was the same in all the cultures, the only difference observable being a slightly deeper tint in the culture on carrot.

Grown on films of maize-meal agar in damp cells, the conidiophores (fig. 16) are about 1 mm. high, and bear branches in whorls in the upper half or two-thirds, distant in the lower part, but crowded above and sometimes forming a loose head. The stalk of the conidiophore is septate, and 1·5μ diameter. The lateral branches (fig. 17) are short and stouter than the stalk, slightly inflated or oval, 4μ long and 2·5μ diameter, and bear at their apices oval basidia, acute above, 4–6μ long and 2–2·5μ diameter. The lateral branches may occur singly, or in whorls of two to six, and the apex of a branch may bear from one to six basidia. In some cases the basidia arise in whorls directly from the main stem of the conidiophore. The spores are borne at the apices of the basidia in chains, in which, under a high magnification, the immature spores appear as if joined by short links. The latter effect appears to be due to the attenuation of the ends of the immature spore. The spores are narrow-oval, 3–4 × 1·2–1·5μ, with ends rounded or subacute. The mycelium is hyaline, septate, 1·5μ diameter, with lateral branches which diminish to a diameter of 0·75μ.

Zimmermann (1901) recorded a second Hyphomycete on *Lecanium viride*, which he referred to as "the fungus of Gierlings," after its discoverer. He stated that it could be distinguished from *Cephalosporium Lecanii* by the naked eye, as it forms much thicker masses round the scale. His figure shows a ring of minute pulvinate masses in contact with one another at the margin of the scale, but this appearance is not uncommon in the case of scales attacked by *Cephalosporium Lecanii*. The conidia were borne in chains at the ends of repeatedly branched hyphae. The dimensions of the conidia were not given and Zimmermann did not name the fungus.

Zimmermann gave three figures, two of which were said to show young conidiophores, while the third is that of an old conidiophore. The third would pass well for a single branch of the Ceylon *Spicaria*: it shows three chains of conidia, each arising from a basidium, situated at the apex of a short branch. The other two figures show branching chains of narrow-oval cells, which produce smaller narrow-oval cells at the septa, the

latter cells bearing at their extremities one or two chains of conidia directly, *i.e.* without basidia. Nothing resembling these two figures has been observed in the Ceylon *Spicaria*, and it does not seem probable that they are related to the species of the third figure.

Bally, in 1923, described under the name *Spicaria javanica* a fungus which occurred on the beetle, *Stephanoderes hampei*, in coffee berries in Java. The hyphae were sparingly septate, white. The conidiophores were profusely branched, very variable in length, 1–2μ diameter, bearing towards the apex numerous branches in whorls. The lateral branches bore at their apices three or four secondary branches (basidia) and from the ends of these arose long chains of conidia. The apex of the stalk of the conidiophore also bore three or four basidia. The conidia were oblong, 2 × 1–1·5μ, at first white, then violet-grey.

In cultures on potato antler-like coremia, 1–3 cm. high, were produced in three or four weeks. These were smooth, dark yellow below, whitish grey at the apex.

Bally's figures show short lateral branches, oval or inflated, broader than the stalk of the conidiophore, and narrow-oval basidia. In these respects his fungus resembles the Ceylon *Spicaria* on *Ceroplastes*, but the apex of the basidium is figured obtuse, and the conidia in the chains have obtuse ends in contact.

Notwithstanding the differences in the figures and the recorded measurements of the conidia, it would appear most probable that the Ceylon fungus on *Ceroplastes*, etc., is *Spicaria javanica*.

Johnston, in 1918, described *Spicaria Aleyrodis*, on *Aleyrodes variabilis* on *Carica papaya*, in Cuba. The conidiophores were hyaline, frequently branched above, with branches in whorls. The lateral branches were short, branching again, and bearing two to four flask-shaped basidia at their apices. The conidia were elliptic or oval, or more or less cylindric, hyaline, 1·6 × 3·3μ. In the dimensions of the conidia, this species approaches the Ceylon *Spicaria*, and it also resembles the latter in its short, oval, lateral branches, but it differs in its flask-shaped basidia, as described and figured by Johnston. I have not seen a specimen.

G. *Gonatorrhodiella coccorum* Petch.

The stromata of *Cephalosporium Lecanii* on *Lecanium viride* sometimes bear minute erect clavae up to 0·5 mm. high. On plating out conidia from these clavae one obtains, in addition to, or instead of, the *Cephalosporium*, a fungus which in some respects resembles a *Gonatorrhodiella*. The clavae usually contain

the hyphae and conidiophores of both fungi. The hyphae of the *Gonatorrhodiella*, as far as they can be distinguished in the clava, resemble long conidiophores with a single lateral branch curving upwards more or less parallel to the main hypha.

This *Gonatorrhodiella* has been found alone on a black *Aleyrodes* on mango, on which it formed a delicate loose white border at the margin of the scale, *i.e.* on the insect, not on the leaf.

On *Aleyrodes* the conidiophores (fig. 18) are up to 0·2 mm. high, lax, suberect, hyaline, septate at close intervals (4–6μ), and 1·5–2μ in diameter. The terminal segment is ovato-conoid, or lanceolate, inflated to a diameter of 3μ, with an obtuse or an acuminate tip. The conidiophores bear chains of spores, arising singly from sterigmata which may be merely protuberances, 0·5μ high, or cylindrical processes, up to 1·5μ high. These sterigmata arise anywhere along the conidiophore, but chiefly just below the septa. Some conidiophores (? the younger) bear one or two sterigmata on each segment, except the terminal one, which is naked (fig. 20). Others (? older) bear sterigmata in a ring immediately below the septa, the apex of the segment being inflated to a diameter of 3μ; and on these conidiophores the terminal segment is usually furnished with several sterigmata (fig. 19). The sterigmata in these latter conidiophores are not confined to the swollen regions immediately below the septa; on some segments all are in that position, but on others one or two sterigmata may be situated near the middle of a segment. In some instances three cylindrical sterigmata may arise close together and spread out fan-wise.

Each sterigma gives rise to a chain of conidia (fig. 21). These chains consequently arise either in whorls from the conidiophore or scattered along its length, with a group of up to at least six from the terminal segment.

The conidia are hyaline, oval, 1.5–3 × 1·2–2μ, or globose, 1·2–2μ diameter, white in mass.

Although this species has, on a first examination, the appearance of a *Gonatorrhodiella*, it differs from the type species, *Gonatorrhodiella parasitica* Thaxter, in several respects. In the latter the conidiophore bears large globose swellings, covered with minute sterigmata, and the chains of conidia arise solely from the swellings, while the terminal swelling bears a dense head of chains of conidia. In *Gonatorrhodiella parasitica* the conidiophore at first terminates in a globose head, densely covered with chains of conidia, like an *Aspergillus*. Growth then occurs from the apex of the head, with the formation of a short stalk and another globose head; and this process is continued until there is produced a long conidiophore, with globose inflations at intervals. Alternatively, two hyphae, or stalks, may arise

from a swelling. The growth of the conidiophore is consequently indefinite, and the swellings represent successive effete heads.

In the fungus on *Aleyrodes* the growth of the conidiophore is definite. It terminates in a differentiated apical segment, and does not subsequently "grow through" that segment. Moreover, the apical segment is formed before the swellings on the conidiophore. At first the conidiophore is regular, and the inflations below the septa appear to be due chiefly to the subsequent development of sterigmata in that position. These sterigmata appear to be formed in succession, not simultaneously, at each septum. Consequently it is doubtful whether this species is correctly referred to *Gonatorrhodiella*.

In culture the fungus departs still more widely from *Gonatorrhodiella*. Platings on neutral Raulin agar, from examples on *Aleyrodes*, gave almost pure cultures; but the structure of the conidiophore differed so greatly that it was at first thought that the species desired had not been obtained. A further comparison with the original fungus, however, showed that the two were really the same.

On neutral Raulin agar, pure white, pulvinate tufts, up to 5 mm. diameter, are formed, consisting of loosely radiating hyphae. The suberect conidiophores are 1·5μ diameter, hyaline, regular, septate at intervals of about 12μ, equal, or very slightly inflated below each septum. The terminal segment is not, or only slightly inflated, and tapers to a blunt apex. Chains of conidia arise from sterigmata of the same size and shape as in nature, but these sterigmata are scattered along the conidiophore, from one to three on each segment, and several on the terminal segment. The majority of the sterigmata are situated below the septa, but they occur singly in that position. Occasionally there may be two sterigmata opposite one another, on either side of the conidiophore, but the whorl of sterigmata which occurs below a septum in nature has not been observed in culture, though the cultures have been kept for two months. Hence the appearance of the conidiophores in culture is quite different from that of the majority of the conidiophores in nature; they are not evidently nodulose when examined under a medium magnification. They can, however, be matched by some of the conidiophores which occur in nature, apparently the younger conidiophores.

On maize-meal agar (tubes) the fungus spreads over the medium in a loose somewhat fleecy layer, the reverse being pale yellow. The growth on Naegeli agar is similar, but thinner. On neutral Raulin agar (tubes) an irregular pulvinate cushiony growth is produced, with a more or less abrupt margin and the reverse is pale ochraceous.

On sterilised potato and carrot, a compact, white, velvety,

pulvinate growth is formed, ultimately entirely covering the substratum. Growth on potato is more luxuriant than on carrot.

Gonatorrhodiella coccorum n.sp. White; conidiophores up to 0·2 mm. high, simple, sometimes branched near the base, sub-erect, lax, hyaline, septate, 1·5–2μ diameter; inflated to 3μ diameter immediately below each septum, terminating in an ovato-conoid or lanceolate segment, about 6μ high and 3μ diameter: conidia in chains, arising from slight protuberances, 0·5μ high, or cylindrical sterigmata, up to 1·5μ high, situated in whorls below the septa, and scattered over the terminal segment and along the conidiophore; conidia hyaline, white in mass, continuous, oval, 1·5–3 × 1·2–2μ, or globose, 1·2–2μ diameter.

CONIOTHYRIUM

Pycnidia which appear to be referable to *Coniothyrium* occur fairly frequently on scale insects attacked by *Cephalosporium Lecanii* in Ceylon. They have also been observed on *Tachardia Albizziae* which was attacked by a *Penicillium*. In general, they are accompanied by a *Cladosporium*. They are probably not parasitic on the insects.

In one collection, on *Lecanium viride* attacked by *Cephalosporium*, the pycnidia were globose, 80–120μ diameter, with a cylindrical truncate ostiolum, 8μ high. The pycnidial wall was thin, parenchymatous, composed of cells 5–8μ diameter, pale fuscous or pale blackish-brown by transmitted light. The spores were fuscous in mass, almost hyaline separately, oval, 2·5 × 1·5μ, or globose, 1·5μ diameter. When the pycnidium was placed in water the spores rapidly oozed out. No chains of spores were detected.

As it is probable that this fungus is merely a common saprophyte which may have been described from some other substratum, it is left unnamed for the present.

In *Trans. Brit. Myc. Soc.* VIII (1923), p. 209, I described a similar fungus, which was found at Hunstanton (England) on *Lepidosaphes ulmi* attacked by *Cephalosporium* (*Acrostalagmus*) *coccorum*. The pycnidia were globose, obscurely ostiolate, up to 80μ diameter, with hyaline, oval spores, 1·5–2 × 1μ, produced in chains. This was referred to *Sirosperma*, as *Sirosperma sparsum*, but on further consideration it would seem preferable that it should be referred to *Coniothyrium*. The Ceylon species would appear to differ in its truncate ostiolum.

It would appear probable that these pycnidial forms are related to the Cladosporiums which occur on scale insects.

Von Höhnel found that the type species of the genus *Coniothyrium* is superficial and astomate. For the species with ostiolate immersed pycnidia, which have hitherto been referred to that genus, he instituted a new genus, *Microsphaeropsis* (*Hedwigia*, LIX (1917), p. 267). The present species are superficial and ostiolate.

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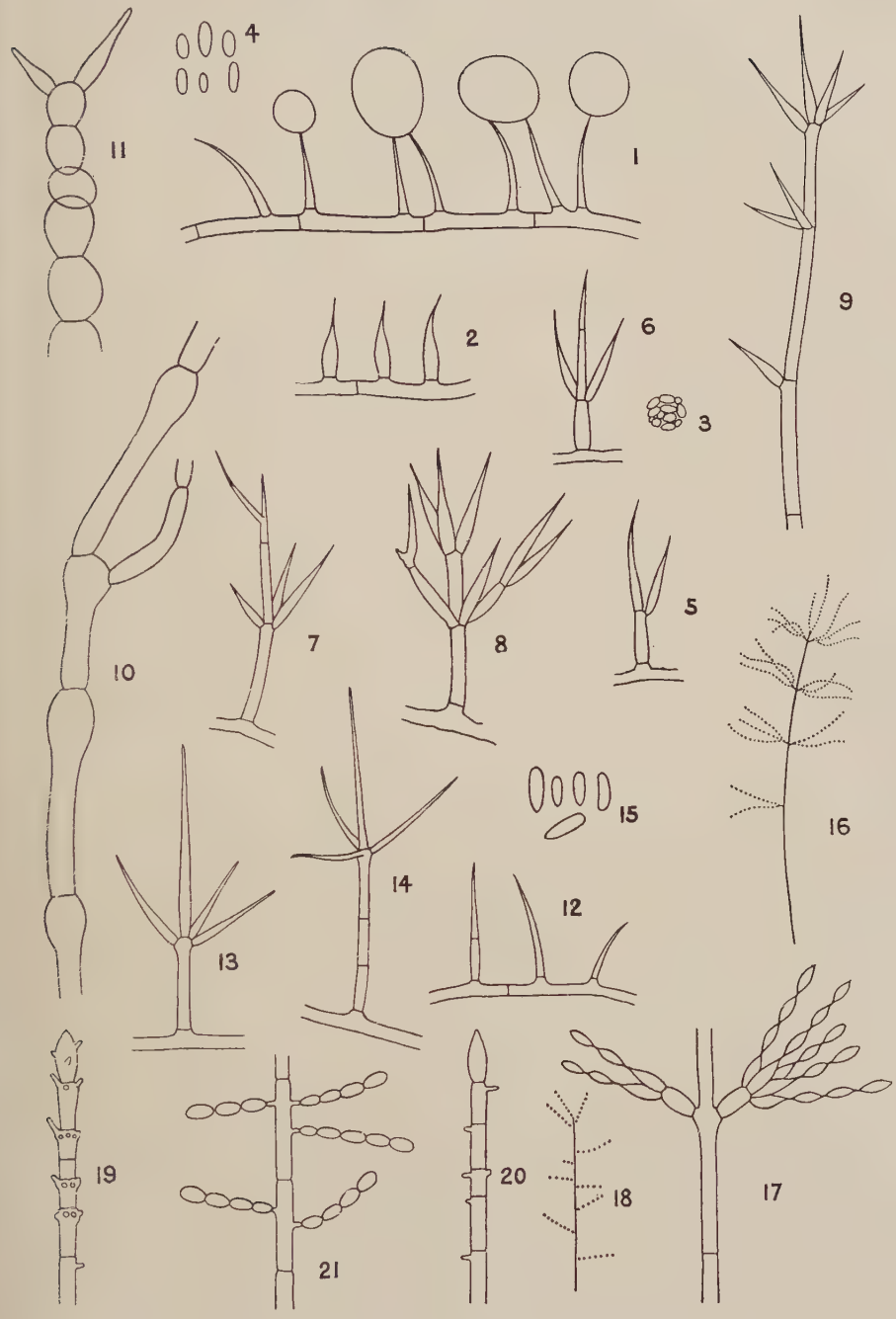
EXPLANATION OF PLATE X.

Fig. 1. Simple conidiophores of *Cephalosporium Lecanii*, heads of conidia in outline.
,, 2. Simple conidiophores of *C. Lecanii* from *Lecanium nigrum*.
,, 3. A head of conidia of *C. Lecanii*.
,, 4. Conidia of *C. Lecanii*.
Figs. 5–8. Branched conidiophores of *C. Lecanii*.
Fig. 9. Upper part of conidiophore from culture of *C. Lecanii*.
,, 10. Mycelium from culture of *C. Lecanii*.
,, 11. Abnormal mycelium and conidiophores from culture of *C. Lecanii*
,, 12. Simple conidiophores of *Cephalosporium coccorum*.
Figs. 13, 14. Branched conidiophores of *C. coccorum*.
Fig. 15. Conidia of *C. coccorum*.
,, 16. Conidiophore of *Spicaria javanica*.
,, 17. *S. javanica*, phialides and conidia.
,, 18. *Gonatorrhodiella coccorum*, conidiophore.
,, 19. *G. coccorum*, old conidiophore.
,, 20. *G. coccorum*, young conidiophore.
,, 21. *G. coccorum*, part of conidiophore from culture.

All figures × 1000, except 16 and 18, which are × 40.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STUDIES IN ENTOMOGENOUS FUNGI.

(With 1 Text-fig.)

VII. SPICARIA.

By T. Petch.

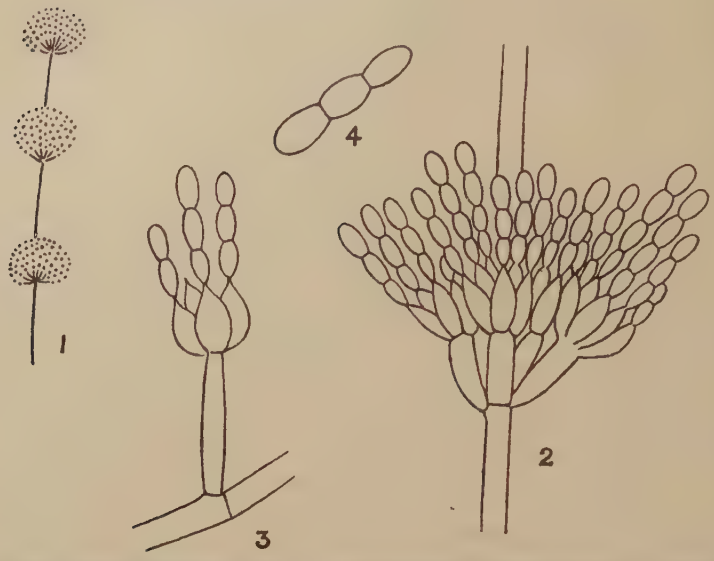
Spicaria prasina (Maubl.) Saw.

This species was first found in Japan by Nomura, and was sent to Maublanc, who instituted for it a new genus, *Nomuraea* (*Bull. Soc. Myc. France*, XIX, 1903, p. 295). It occurred on the larvae of *Pionea forficalis*. The genus *Nomuraea* was described as having short, erect, simple conidiophores, which bore ovoid ramuli in whorls; the conidia were ovoid, continuous, pallid, in short chains at the apices of the ramuli. The species, *Nomuraea prasina* Maubl., was described as "effusa, prasina, larvas omnino obducens; hyphis tenuibus, 2–3μ crassis; conidiis ovoideis, basi leniter attenuatis, pallide virescentibus, 4 × 2–3μ." The figure of the conidiophore shows rather close-set whorls of ramuli, while an enlarged figure of a whorl shows correctly (and contrary to the description) that the chains of conidia arise from secondary ramuli.

Sawada transferred this species to *Spicaria*, and it appears under the latter name in his *Descriptive Catalogue of Formosan Fungi* (1919).

I have specimens of this fungus on larvae of *Spodoptera mauritia* Boisd., Suduganga, Ceylon, December 23, 1919, coll. R. Senior White; on an undetermined larva on *Girardinia heterophylla* Dcne., Hakgala, Ceylon, April 11, 1924, coll. G. M. Henry; and on larvae of *Anticarsia gemmatilis* Hubn., on velvet bean, Gainesville, Florida, U.S.A., September 9, 1923, per Dr A. H. Beyer.

The affected larvae are first covered by a rather thin white felt of hyphae, from which arise suberect conidiophores, up to 150μ high, close together, forming a somewhat compact, pale-green pile. In nature the conidiophores are 1·5–2μ diameter, and bear whorls of ramuli at distances of 12 to 25μ. The ramuli and conidia form dense clusters, more or less globose, encircling the stem of the conidiophore. The appearance of the conidiophore differs from that of *Spicaria* in general, the stem being beaded at intervals with globose clusters, approximately of the same size. Several primary ramuli are situated in each whorl, completely surrounding the stem, and each bears at its apex a number of secondary ramuli (basidia). In Vuillemin's nomenclature, the fungus has phialides and prophialides. The primary ramuli (prophialides) are ovoid or cylindric, 4–6 × 2·5–3μ; the



Spicaria prasina (Maubl.) Saw. 1, conidiophore (diagrammatic); 2, whorl of phialides and conidia, ×1500; 3, a solitary branch bearing phialides, ×1500; 4, part of a chain of conidia, ×1500.

secondary ramuli (phialides) are ovoid or subcymbiform, 4 × 3μ, shortly acute at the apex. The conidia are pale green in mass, greenish hyaline individually, thick-walled, oval, 2–3 × 1·5–2μ, or globose, 1·5μ, borne in chains and united to one another over a comparatively wide area. In culture the conidia are rather larger, 3·5–4·5 × 2–2·5μ, narrow-oval, with obtuse ends, or sometimes with one end subacute; and the conidiophores are up to 3μ diameter. The conidia adhere to one another.

In some instances a cluster of secondary ramuli arises at the apex of a short lateral branch about 12μ long. Such branches arise just below the whorl of primary ramuli, and the head of conidia forms part of the cluster produced by the whorl.

Examples collected in Florida on September 9, 1923, were received in Ceylon on October 22, 1923, and cultures were immediately attempted. No germination of the conidia could be obtained on maize-meal agar, bean agar, Dox agar, Naegeli agar, or Raulin neutral agar.

Conidia from the Ceylon specimen of April 11, 1924, were sown on maize-meal agar and bean agar immediately on receipt and within a few days of collection. Growth occurred, but was very slow, nothing being visible macroscopically until five days afterwards. A month later (May 14) conidia from the insect

were plated out on maize-meal agar, but no growth resulted. Thus the conidia either lose their capacity for germination, or pass into a resting condition, comparatively early.

The cultures on maize-meal agar, begun on April 11, produced a white, thin, somewhat cottony mycelium. No conidia were evident until May 14, when a continuous, pale sea-green patch began to appear, usually at the lower margin of the colony. Transfers of conidia from one of these cultures were made on May 20; growth was evident in two days, and conidiophores appeared on May 28. In the first cultures the conidiophores formed a continuous even pile over limited areas at the margin of the colony, the remainder persisting white. In the second series the colonies had a loosely-pulvinate white centre, and a broad, flat, pale sea-green margin. On the fourth transfer extensive, uniformly flat, green colonies, with a narrow white margin, were produced.

The cultures on bean agar, begun on April 11, formed a denser, more compact, cream-coloured stroma, and spread thence in a broad, white, thin, marginal zone. Conidia were not produced until June 1, when they appeared on marginal patches similar to those of the maize-meal cultures.

Maize-meal agar is reddened by the growth of the fungus.

On 20 per cent. gelatine growth was poor. Small, thin, white patches were formed, red-brown with a white edge on the reverse. A few minute tufts of conidiophores were produced at the end of sixteen days. The gelatine was liquefied in the neighbourhood of each patch, but liquefaction did not occur throughout the tube. The gelatine was not coloured.

On Naegeli agar with cane sugar, growth was again poor. Small, white, pulvinate tufts were formed, with a somewhat radial structure. The reverse was red-brown to orange-red, but the agar was not coloured. After seven weeks the largest patch was only 1 cm. diameter, and no conidia had been produced.

On Dox agar growth was even more scanty than on the two previous media. Very minute white patches were formed, which at the end of a fortnight were not yet dense enough to show a distinct colour on the reverse. A minute green point of conidiophores was produced in the centre of the patch. The patches did not increase in size on the surface, but a quantity of submerged mycelium developed after three weeks. The reverse was ultimately white, and the agar was not coloured.

On Raulin neutral agar the development was good. The mycelium was thin at first, but extensive, and inclined to be byssoid. Conidia were produced in a week, but only on limited areas of the stroma. After six weeks the thicker parts of the stroma and the greater part of the thinner areas were still

sterile. The conidiophores were more scattered than on maize-meal agar. The reverse was deep orange-red, but the agar was not coloured.

On Raulin agar very slight growth occurred. Small floating patches were formed, the largest about 5 × 2 mm. These were flesh-coloured to purplish on the reverse. No conidia had been produced at the end of six weeks.

Growth of this species was best on maize-meal agar. On that medium the fungus develops an extensive white mycelium which bears definite, flat, continuous patches of conidiophores, usually at the margin of the culture. These patches may extend across the tube; and for a breadth of 5 mm. After repeated transfers, the whole of the colony bears conidiophores except at the extreme edge.

Spicaria Araneae Sawada.

I have specimens which I take to be this species, on a spider, Hakgala, Ceylon, May, 1912, and on a spider, Vavuniya, Ceylon, December, 1923, the latter collected by Mr G. M. Henry. The Ceylon fungus agrees with Sawada's figures, but as the only description I have seen is in Japanese, there is doubt whether the colour is the same. The specimen from Hakgala was a bright rose or purple-rose when fresh, becoming rose-purple when dry; the Vavuniya specimen was rose-purple when received.

The fungus covers the body of the spider with a continuous even pile of conidiophores, about 100μ thick, so dense that at first sight its fungal nature is not evident. The surface is minutely pulverulent. The conidiophores are more or less erect, up to 4μ diameter, and bear globose clusters of conidia at short intervals, exactly as in *Spicaria prasina*. The primary ramuli are oblong-oval or clavate, 4–5 × 2–3μ; the secondary ramuli are cylindric, narrow-oval or clavate, 4–4·5 × 2–2·5μ. The conidia are borne in chains, each chain from a very minute sterigma in the centre of the apex of a secondary ramulus; they are usually thick-walled, hyaline, oblong-oval, 4–6 × 2μ, or narrow-oval, 3–4 × 1·5–2·5μ, or globose, 2–2·5μ, and are broadly united in the chain.

On maize-meal agar inoculated with conidia, growth was slow at first, nothing being visible until the fifth day. Small white patches of mycelium were produced, which after thirteen days had become pulvinate tufts of conidiophores, pale rose-purple or purple-grey, up to 4 mm. diameter, with a narrow white margin. This pseudo-sporodochial mode of growth was very marked at first, and contrasted strongly with the diffuse growth of the conidiophores of *Spicaria javanica* and the flat patches of conidiophores in *S. prasina*. After several transfers it was

to some extent lost, as the fungus then formed a continuous white mycelium over the whole slant. The conidiophores, however, were still produced in isolated pulvinate tufts. The rose tinge becomes fainter in culture.

Maize-meal agar is not coloured by the growth of the fungus.

On 20 per cent. gelatine growth is good, but as the gelatine is completely liquefied the mycelium is at first almost entirely submerged, and conidiophores are produced only in minute tufts, unless on mycelium adherent to the sides of the tube. The latter patches, and floating patches formed later, are pale yellow, then pale purple-red, and finally purple-red, on the reverse, while the gelatine becomes reddish-brown, and at the end of about two months, blood red.

On Naegeli agar with cane sugar growth is slow. Formation of conidia did not begin until after twenty-four days in the first series of cultures, and not until the expiration of sixty-six days in the second. One tube of the latter did not produce any conidia in three months. A white, loose mycelium is formed which does not extend for more than about 2 cm. The reverse is at first pale yellow, becoming yellow-brown in two months. The agar was not coloured.

On Dox agar growth of the mycelium was better than on maize-meal or Naegeli agar, a white mycelium covering almost the whole slant. Conidia were not produced until the expiration of thirty days. The reverse is olive-brown at first, becoming yellow-brown to red-brown, and the agar is coloured yellow-brown.

On Dox and Naegeli agar the masses of conidia are bluish-purple.

On Raulin neutral agar growth is slow at first, but by the end of a month a dense woolly growth is formed, which settles down in thick, white, fleecy masses. Conidia were produced in three weeks. The reverse is pale yellow at first, becoming brownish-yellow, and finally red-brown to yellow-brown. The agar is not coloured.

In 1910 Vuillemin described a rose-coloured *Spicaria* as *Spicaria Aphodii*. It occurred on a coleopteron (*Aphodius fimetarius*) and also on vegetable debris. In a later publication (1911) he expressed a doubt whether his species was not identical with *Sporotrichum roseum* Link. I have not been able to consult Vuillemin's original paper, with the figures of *Spicaria Aphodii*, but it would appear from the description that it is not the same as *S. Araneae*.

Spicaria Aphodii, according to the description quoted by

Sartory, appeared on the body of the insect in scattered rose-coloured masses. Its mycelium was about 3μ diameter, the conidiophores being more slender and attenuated upwards. The latter bore whorls at intervals varying from 20μ below to 6μ above. The upper whorls consisted of phialides, the lower of branched ramuli, bearing groups of phialides at their apices. The phialides were flask-shaped, and consisted of a lower oval part, 4 × 2·6μ, and a neck 3–3·5μ long, 1μ diameter at the base, 0·2–0·3μ diameter at the apex. The conidia were rose-coloured, oval, 3·5–4 × 1·5–1·75μ, scarcely acute at the lower end. On the insect the conidiophores are reduced, the branches forming swollen polyhedral segments which support a continuous layer of phialides.

Spicaria javanica Bally has been described in a previous paper "*Cephalosporium* and associated fungi."* It differs from both *S. prasina* and *S. Araneae* in its morphological and cultural characters.

Spicaria Aleyrodis Johnst. was described by Johnston in 1918 from specimens on *Aleyrodes variabilis* on *Carica papaya* in Cuba. The conidiophores have whorls of short primary ramuli, each of which bears two to four flask-shaped secondary ramuli (phialides). The conidia are elliptic or oval, or more or less cylindric, hyaline, 1·6 × 3·3μ. The primary ramuli are oval. I have not seen a specimen of this. Presumably it is white. It differs from *S. javanica*, according to the description, in its flask-shaped phialides. Cultural details are not available.

In 1911 Fron described a fungus, which occurred on cocoons of *Cochylis ambiguella*, as *Spicaria verticillioides*. The chrysalis was covered with a white mould, which formed a thin coat over the body, but was thicker over the head. The phialides were flask-shaped, 5–7μ long, and the conidia 3–4 × 2–2·5μ. The conidia were said to be laxly catenulate, and in the figure they are shown as united by attenuated ends, as in *S. javanica*. Fron stated that in a young culture the phialides occurred in groups of two to four at the same level or at the apex of a hypha, so that the fungus had a verticillate arrangement; hence his choice of the specific name. His figures leave one in doubt whether they represent repent hyphae, with short lateral branches bearing phialides, or erect conidiophores with whorls of prophialides and phialides, but it would seem most probable that the former was intended.

In a later paper Fron recorded that his fungus produced *Isaria* forms in culture, and stated that it should perhaps be referred to *Isaria farinosa* Fr. He then named it "*Spicaria farinosa verticillioides* (*Isaria farinosa affinis*)." Sauvageau and

* p. 175.

Perraud had studied a fungus on *Cochylis ambiguella* in 1893, and had referred it to *Isaria farinosa*. Picard (1914) states that the fungus described by Fron is undoubtedly that of Sauvageau and Perraud, and is the species which has always been regarded by the majority of naturalists as *I. farinosa*. It is to be noted that the Tulasnes' figures of the latter species show a *Spicaria* conidiophore.

In 1916 Portier and Sartory described *Spicaria Cossus* from a specimen on larvae of *Cossus*. It formed a pinkish white covering over the insect. The hyphae were 2·5–4μ diameter, and bore more slender conidiophores which were attenuated upwards. The conidiophores bore whorls at intervals of 25μ below and 5–7μ towards the apex. The upper whorls consisted of phialides, but the lower were composed of branches which divided several times before terminating in groups of phialides. The phialides were broadly oval, attenuated above, or broadly flask-shaped, 4 × 2·6–3·5μ. The conidia were ovoid, 3–4 × 1·5–1·8μ. The fungus was said to grow well on both acid and neutral Raulin's fluid. In culture it sometimes produced coremia. The mycelium was white in culture, becoming pale cream on the development of the conidia. Except in the length of the neck of the phialides, this species would appear to resemble *S. Aphodii* on morphological characters.

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ENTOMOGENOUS FUNGI: ADDITIONS AND CORRECTIONS.

By T. Petch.

Herr H. Sydow has kindly submitted to me specimens of several species of entomogenous fungi which were described by him in 1916–17 and which were not available when my account of the genera *Hypocrella* and *Aschersonia* (*Ann. Perad.* vii (1921), pp. 167–278) was written. In some instances these necessitate an alteration of the name adopted in that paper. Descriptions of these and of other species which have recently been found are given below, together with further notes on the distribution of known species, and on some concerning which little information was available previously.

HYPOCRELLA AND ASCHERSONIA.

Hypocrella aurea Syd., *Engler's Bot. Jahrb.* liv (1916), p. 256, on leaves of an undetermined shrub, New Guinea. The stromata, according to the original description, were vivid golden. In the herbarium specimens they are reddish-yellow, pruinose, pulvinate or subglobose, contracted below, tuberculate, 1 mm. diameter, 0·7 mm. high, with a membranous hypothallus, 0·5 mm. broad. The ostiola are red-brown, conspicuous, slightly elevated. Internally the stroma is yellow towards the periphery and white in the centre. With caustic potash the yellow part becomes vivid purple-red, but the white tissue is scarcely coloured. The stroma is rather loose in texture and crumbles on cutting. The perithecia are flask-shaped, up to 0·5 mm. deep, 0·2 to 0·25 mm. diameter, with a yellow wall, 25μ thick. The asci are 8μ in diameter (9–12μ Sydow). In one ascus the part-spores were cylindric, ends square, 4–7 × 2μ; in another they were narrow-oval, with truncate ends, 8–10 × 2·5μ. Sydow's measurement of the cylindrical part-spores is 4–7 × 2μ. The fungus is parasitic on a *Lecanium*.

H. aurea resembles *H. javanica* in all respects, except that the stroma is softer. I do not think it can be maintained distinct from the latter.

Hypocrella sphaeroidea Syd., *loc. cit.*, on stems of a climbing plant, New Guinea. This is the species referred by von Höhnel to *Fleischeria sclerotioides*, and described by me as *Hypocrella olivacea* (*Ann. Perad.* vii (1921), p. 206). The latter name is antedated by Sydow's.

Hypocrella insignis Syd., *loc. cit.*, on a fallen leaf, New Guinea. The stromata are circular, almost plane, 12 mm. diameter, 0·75 mm. thick, vermilion, slightly darker in the centre, with

minute, scattered, black ostiola, more especially towards the margin. This is a flat form of *H. ceramichroa* (B. & Br.) Petch.

Hypocrella plana Syd., *op. cit.*, p. 257, on living leaves of *Piper* sp., New Guinea. The stromata in some cases are up to 4 mm. diameter, circular, almost plane, with scattered perithecial elevations, each with one perithecium, tomentose, with a thin, sometimes fimbriate margin. Other examples are oval, without a thin margin, flattened pulvinate, undulating, slightly tomentose, with scattered brown ostiola. The fungus is on an Aleyrodid. The latter specimens are exactly *H. Mollii* Koord., while the former are a frequent variation from the typical form.

Hypocrella vilis Syd., *Ann. Myc.* xv (1917), p. 215, on *Schizostachyon*, Angat, Province of Bulacan, Luzon, Philippine Is. The stromata are up to 0·8 mm. diameter, circular, flattened pulvinate, almost plane, tomentose, with a fimbriate margin, and in the herbarium specimens white or yellowish-white. Some bear waxy patches of conidia, not covering the whole of the stroma. In other cases the scale insect bears separate conidial patches, 0·2 mm. diameter, each with its own byssoid margin. The conidia are narrow-oval, continuous, 3–6 × 1·5–2μ, or globose, 2μ diameter, on conidiophores 12μ high. The perithecia are embedded in the conidial stroma, scattered or clustered, dark red-brown or yellow-brown, up to 0·12 mm. diameter. The wall, by transmitted light, is pale brownish-yellow, of obscure structure. The asci are eight-spored, with narrow-oval, one-septate, ascospores, 6–8 × 2–2·5μ; a few subglobose spores are present.

The conidial stage is *Tubercularia coccicola* Stev., and the perithecial stage is identical with *Nectria Tuberculariae* Petch (*Trans. Brit. Myc. Soc.* vii (1921), p. 157). The latter name is antedated by Sydow's, and as the combination, *Nectria vilis*, does not appear to have been employed, the species will now stand as *Nectria vilis* (Syd.) Petch.

Hypocrella libera Syd., *Ann. Myc.* xiv (1916), p. 85, on coccids on fallen leaves, Bolivia, Cobija, Rio Acre; Ule, No. 3413. The stromata are up to 10 × 6 mm., or larger by confluence, and consist of a thin basal layer, almost entirely hidden by erect processes, the whole surrounded by a white, fimbriate margin. The basal disc is up to 0·5 mm. thick, tomentose, compact but fragile, interrupted here and there, and cracking on drying. The processes are clustered, sometimes two or three confluent, ovato-conoid, constricted below, minutely tomentose, white or yellowish-white, 0·8 mm. high, 0·5–0·6 mm. diameter, apices obtuse, glabrous, amber or pale yellow-brown. The perithecia are embedded in the processes, usually one in each. The perithecial wall is hyaline and about 60μ thick, while the stromatic

tissue surrounding the perithecium is 150–250μ thick at the sides and 250μ thick at the base. This stromatic tissue is somewhat loosely attached to the wall of the perithecium, and the latter is easily dissected out. On cutting sections of the processes, the perithecium may separate from the surrounding tissue; but this tissue consists of interwoven agglutinated thick-walled hyphae, not merely loose tomentum. The outer tomentose layer consists of thick-walled hyphae, 3–4μ diameter, smooth or verrucose, flexuose or curved, about 40μ long, usually with short rectangular lumina.

The asci are up to 450μ long, 7–10μ diameter, becoming 15μ diameter when the spores are mature. The part-spores are straight or curved, oblong-oval, or cylindric and tapering slightly to the truncate or rounded ends, or sometimes with one side straight and the other curved, 8–20 × 2–2·5μ; the contents are often contracted away from the ends and divided into two parts.

In the centre of one stroma there occurred a cavity overgrown by the stroma and processes, and lined with a yellow-brown horny mass. Embedded in this mass were typical *Aschersonia* spores, narrow-fusoid, with acute tips, 10–16 × 1·5μ. Paraphyses could not be detected. The base of the cavity was not convoluted. The general appearance is that of an Aleyrodid *Aschersonia*, and it may be that the paraphyses had become disorganised.

This species is identical with *Hypocrella nectrioides* Thaxter, *Ann. Perad.* VII (1921), p. 225. The type of the latter has much smaller stromata, but is identical in other respects, and the stromata similarly sometimes have effete *Aschersonia* loculi embedded in them. The part-spores of the two species are the same, the measurement previously given for *Hypocrella nectrioides* being too small; a re-examination of the type of the latter gave the dimensions 10–20 × 2–2·5μ.

From Professor Thaxter I have received two collections of apparently the same species on a scale on *Inga edulis*, collected by J. R. Johnston at Chaguinola, Panama. In these the stromata are pale yellow, minutely pruinose, up to 1 cm. diameter, usually thin, sometimes slightly pulvinate in the centre. The central part, up to 5 mm. diameter, is opaque and compact, and merges gradually into a broad, scarious or fibrillose hypothallus. In some examples the central portion bears pycnidia, the pycnidial orifices being small, oval, yellow-brown, circularly arranged in the thinner forms, but scattered in one, more pulvinate, specimen; in one case the pycnidia are arranged in two concentric circles. At the margin of the pycnidial stromata, or scattered over the non-pycnidial examples, are erect, ovoid-

cylindric processes, white to yellowish, paler than the stroma, minutely tomentose, glabrous and subtranslucent at the apex, up to 0·5 mm. diameter and 0·3 mm. high, each containing a perithecium. The asci are chiefly immature, but some part-spores were found; these were cylindric, ends rounded, or ovoid-cylindric, ends truncate, 8–12 × 2–2·5μ.

The pycnidia in the pulvinate specimen are ovoid or sub-cylindric, up to 0·5 mm. deep, 0·25 mm. diameter. The pycnospores are fusoid, inæquilateral, acute, 10–12 × 1·5–2μ, and are accompanied by paraphyses up to 80μ long.

This pycnidial stage is *Aschersonia Aleyrodis*. Consequently *Hypocrella libera* Syd. is the perithecial stage of *Aschersonia Aleyrodis*. The general structure of *Hypocrella libera* and *Aschersonia Aleyrodis* is similar to that of *Hypocrella Raciborskii* and *Aschersonia placenta*.

Sawada, in *Descriptive Catalogue of the Formosan Fungi* (Dec. 1919), records *Hypocrella Aleyrodis* (Webb.) Sawada, with the synonyms *Aschersonia Aleyrodis* Webber and *Hypocrella Raciborskii* Zimm. *Hypocrella Raciborskii*, however, is the perithecial stage of *Aschersonia placenta* B. & Br., which, in my opinion, is distinct from *A. Aleyrodis* Webber. The records of the latter for Japan appear to be erroneous, the Eastern species being *A. placenta*. Consequently, *Hypocrella Aleyrodis* (Webb.) Sawada is not the same species as *H. libera* Syd., and in any case it is antedated by *H. Raciborskii*.

Hypocrella Gaertneriana Möll. Specimens which appear to be referable to this species have been forwarded to me by Prof. Thaxter. They were collected by Rick, at Nova Petropolis, Brazil, on the stem of a bamboo. The stromata are irregularly flattened-pulvinate, up to 7 mm. diameter and 3 mm. high, and consist of several contiguous lobes arising from a rather thin, expanded base. There may be two or three equal lobes, distorted and angular along the lines of contact, or one large lobe with one or more smaller lobes at the side, or the stroma may be simple, *i.e.* reduced to one, regular, flattened-pulvinate lobe. The general appearance of the larger compound stromata gives the impression, at first sight, that they are clusters of stromata arising from several insects situated close together on the stem, each stroma based on a single insect, especially as simple stromata occur in the same collection. But examination shows that all the lobes arise from a common base, and under the base there is only one of the characteristic scars which denote the situation of the insect.

The lobes of the stroma arise from the central parts of the base, and extend outwards beyond the base, with their outer edges in contact (or nearly so) with the stem. In the simple

stromata, a stout, but short, stalk arises from the centre of the base, and the stroma in its subsequent growth extends not only upwards and horizontally, but also downwards, so that the stalk is ultimately buried in it. In some examples, a narrow horizontal groove is present between the base and the lobes of the stroma. In this latter feature the fungus recalls *Aschersonia basicystis*.

In the recent specimens the stroma is deep chocolate-brown in colour, with a grey, or pale brown, pruinose, superficial layer which rubs off. The ostiola are black, conspicuous, either slightly projecting or not. Internally the stromata are pallid or greyish, somewhat subtranslucent, except in the centre which is white and opaque. The cortical zone, in section, is brown or yellow-brown. The perithecia are rather densely crowded in a peripheral zone, and are narrow flask-shaped, up to 450μ high and 150μ diameter, with a hyaline wall. The asci are four- or eight-spored. The ascospores are 1–1·5μ in diameter, about as long as the ascus, in a parallel bundle which is only slightly twisted. They are immature in these examples, but a few have septa 9–15μ apart. Part-spores have not been observed. The stroma does not give any colour with caustic potash.

Möller described the stroma of *Hypocrella Gaertneriana* as yellow, with dark ostiola, several centimetres diameter, with close-set tubercles. His figure shows a specimen, 3·3 cm. diameter, larger and much more lobed than the recent examples. It would appear that the yellow colour fades with age. He stated that the part-spores were 4–6μ long and 1·5μ broad. I have not seen the type specimen, but only a slide from Dr Möller.

Hypocrella disjuncta Seaver. This species was very briefly described by Seaver in *Mycologia*, XII (1920), pp. 93–98. It was said by the collectors to be on "White fly" on *Bignonia unguis* L., Porto Rico, but as it is described as perched on the rather large ellipsoid scale so that the insect is distinctly visible, it would appear to have been on a *Lecanium*. The details given do not reveal any differences from *Hypocrella phyllogena* (Mont.) Speg.

Hypocrella cretacea v. Höhnel. This is recorded by Seaver (*loc. cit.*) as common in Porto Rico on *Adiantum*, chiefly in the *Aschersonia* stage. His figure shows pycnospores with attenuated tips, quite different from those of *Hypocrella cretacea*, and resembling those of *H. phyllogena*. The fungus would appear to be the flat form of the latter species.

Hypocrella hypocreoidea Petch. The *Hypocrella* stage of *Aschersonia hypocreoidea* (Cke. and Massee) Petch has been collected on a Rubiaceous plant at Kitulgala, Ceylon, March 1924. The stromata are pulvinate, up to 2 mm. diameter, or thin and flattened, up to 3·5 mm. diameter, orange-yellow, fading to

cream, tomentose, with or without a scarious hypothallus. They bear erect, ovoid processes, scattered or clustered, up to 0·4 mm. high, 0·3 mm. diameter, rounded above, orange-red at the apex, pruinose or rough with rather large, scattered masses of cells. Each process contains one perithecium. The perithecia are immature. Separate *Aschersonia* stromata occurred with the *Hypocrella*.

Aschersonia paraensis P. Henn. The specimens issued under this name in Baker, *Fungi Malayana*, No. 203, on *Psidium Guayava*, Mt Maquiling, Philippines, are *Aschersonia Coffeae* P. Henn.

Aschersonia sclerotioides P. Henn. The specimens issued under this name in Baker, *Fungi Malayana*, No. 204, on scale on *Citrus*, Mt Maquiling, Philippines, are *Aschersonia samoensis* P. Henn.

Aschersonia caespiticia Syd., Engler's *Bot. Jahrb.* LIV (1916), p. 260, on a living leaf, New Guinea, Ledermann 6856. Stromata hemispherical, 1–3 mm. diameter, pulvinate, "ochraceo-succinea"; pycnidia numerous, densely crowded, strongly projecting, ovate, up to 0·5 mm. long, 0·33 mm. broad; pycnospores acicular, ends acute, 8–10 × 1μ; basidia filiform, 15–20 × 1μ. The foregoing is taken from Sydow's description. I have not seen a specimen. Apparently this is a lecaniicolous species, resembling the *Aschersonia* stage of *Hypocrella sphaeroidea*, except in colour. In the latter respect it appears to agree with some forms of *Aschersonia marginata*, in which the pycnidia usually do not project and are either ovate or tubular.

Aschersonia duplex Berk. Specimens of this species from New Zealand on a scale on *Hedycarya arborea*, kindly forwarded by Mr G. H. Cunningham, have paraphyses up to 180μ long instead of 80μ as in the type.

Aschersonia marginata E. & E. Mr C. C. Brittlebank has kindly forwarded me specimens of this species from Australia. It occurred on *Citrus* at Townsville, Queensland. This is the first record of the species for that continent. I have also received specimens from Madagascar, *per* Mr E. E. Green, on a scale on *Citrus*, and on *Lecanium coffeae*; and from New Guinea, *per* Dr G. Bryce, on *Albizzia Lebbex* Benth.

ASCHERSONIA PAPILLATA n.sp. Stromata hard, flattened-pulvinate, sometimes depressed in the centre, up to 2·75 mm. diameter, 0·8 mm. high, subtranslucent, pallid yellow or dark honey-coloured, covered with close-set, pulvinate, subcylindric, or conoid translucent elevations, up to 0·06 mm. diameter, 0·05 mm. high, which are distinctly ostiolate when the pycnidia are mature, pruinose at first between the elevations; margin usually white, fimbriate, thinning out gradually, sometimes rounded, sometimes stout, up to 0·5 mm. broad, recurved, con-

colorous with the stroma, with a white edge; pycnidia vertically oval, 0·2–0·4 mm. high, 0·1–0·2 mm. diameter; pycnospores narrow-fusoid, 12–16 × 1–1·5μ, sometimes spuriously one-septate; paraphyses up to 150μ long. On a black Aleyrodid on *Citrus*, Hatton, Ceylon, July 7, 1922. In specimens depressed in the centre, the remains of the insect are present in the depression in the upper part of the stroma. Caustic potash colours a section of the stroma greenish-yellow to brownish-yellow, and sometimes gives a brownish-yellow extract.

PODONECTRIA.

Podonectria coccicola (Ell. & Everh.) Petch has been forwarded by Mr C. C. Brittlebank from Australia; it occurred on a scale on *Citrus*, Townsville, Queensland. This makes it probable that *Microcera rectispora* Cke. and Massee, which has previously been shown to be a *Tetracrium*, is identical with *Tetracrium coccicolum* v. H., the conidial stage of *Podonectria coccicola*.

Tetracrium coccicolum v. H. has been found on *Chionaspis Manni* on tea from Darjeeling.

BROOMELLA.

Broomella Ichnaspidis. This species was described by Zimmermann in *Centralb. f. Bakt.* Abt. II, VII (1901), p. 876. In *Trans. Brit. Myc. Soc.* VII, p. 27, the writer pointed out that from the figure and description it was not a *Broomella*. Von Höhnel, in *Ann. Myc.* XVIII, p. 75, referred it to *Oomyces*, judging from the description and figure. Zimmermann described it as having a stroma only slightly elevated above the scale insect, which bore protuberances containing perithecia. From his figure each protuberance contained a single perithecium, sharply differentiated from the stroma, and, when mature, embedded in the stroma only to about half its height. The outer layer of the perithecium wall was hyaline, the inner layers blood-red. The red colour disappeared on heating in chloral hydrate, but in the projecting part of the perithecium, the wall, and especially the ostiolum, remained brown. The general colour of the whole fungus was not given. The asci were 95–120μ long, and contained eight hyaline linear spores, almost as long as the ascus, 4–5μ broad, multiseptate, with up to 16 septa, attenuated towards one end. Zimmermann also described a var. *major*, in which the asci were up to 170μ long, with ascospores up to 155μ long and not attenuated. As previously stated, the ascospores figured resemble those of *Podonectria coccicola* (Ell. & Everh.) Petch.

Recently I received specimens of scale insect fungi on leaves of *Citrus medica* from Malang, Java, kindly sent by Dr K. Friederichs. Though the collection consisted of half-a-dozen leaves only, it included *Sphaerostilbe coccidophthora*, *Lisea Par-*

latoriae, *Myriangium* sp., and *Podonectria coccicola*, with its conidial stage, *Tetracrium coccicolum*.

The ascospores of the *Podonectria* were closely septate and 6–7μ broad. A few stromata, however, were different. These had the usual byssoid stroma overlying the scale, sparsely covered with thick-walled perithecia, but the thick brown outer parenchymatous layer terminated abruptly at about two-thirds the height of the perithecium, leaving the upper part conical, black and glabrous. The appearance of these perithecia is exactly that of Zimmermann's *Broomella*. The hyaline layer noted by Zimmermann is strongly reticulated and composed of large cells, as compared with the small brown cells of the thick parenchymatous wall. It appears to be external on the upper glabrous part of the perithecium, and to underlie the thick outer parenchymatous layer in the lower part. The asci of these perithecia were 150–165 × 16–18μ, accompanied by numerous linear paraphyses, and the ascospores, 140–160 × 4μ, closely septate, with septa, 5–8μ apart, elongated fusoid, with obtuse tips. No red was observable in these specimens. The perithecia were ovate, up to 0·4 mm. diameter.

In one or two other stromata, however, the broken perithecia showed a vermilion interior. But in these the perithecia were uniformly dark brown externally and thick-walled, the outer parenchymatous layer being continued over the apex of the perithecium. The red colour quickly disappeared in alcohol, leaving the cells brown. The perithecia were minute, globose, about 0·2 mm. diameter. The ascospores were 4μ broad, and multiseptate, identical with those of the previous specimens.

Judging from these specimens it would appear that Zimmermann's *Broomella* is a *Podonectria* in which the thick outer parenchymatous layer is lacking over the apex of the perithecium. But, whereas Zimmermann found such perithecia with a red inner layer, in the present case the perithecial wall of exactly similar perithecia is brown, and the red coloration occurs in perithecia which have a normal, uniformly thick wall. Consequently it would seem that neither of Zimmermann's characters is constant, and the circumstances suggest that both are abnormalities of *Podonectria coccicola*. The specimens differ from the average examples of *P. coccicola* in the close septation of the ascospores and their small breadth. *P. coccicola* has ascospores which, as a rule, vary in breadth from 7 to 9μ. But the undoubted specimens of *P. coccicola* in the present collection have ascospores just as closely septate, and only 6–7μ broad.

The final decision as to the identity of *Broomella Ichnaspidis* must await the discovery of further specimens, but it would seem quite certain that it is a *Podonectria*.

NECTRIA.

Tuberculariacoccicola Stev., the conidial stage of *Nectria vilis* was found on *Lecanium hemisphericum* on tea, Yarravale, Ceylon, August 29, 1922, and on *Ceroplastes* sp., on *Santalum album*, Peradeniya, Ceylon, September 1922.

SPHAEROSTILBE.

Sphaerostilbe coccidophthora (Zimm.) Petch. In "Nectriae parasitic on Scale Insects" (*Trans. Brit. Myc. Soc.* VII (1921), p. 132), reference was made to a specimen on *Asterolecanium miliaris* on bamboo, which resembled *Sphaerostilbe coccidophthora* as regards the structure of the perithecia, but in which ascospores were found measuring 21–27 × 9–10μ. The usual dimensions of the ascospores in that species lie within the limits, 13–22 × 7–9μ. In a recent collection of *S. coccidophthora* on a *Chionaspis* on *Santalum album*, Peradeniya, September 20, 1922, the ascospores measured 13–17 × 7–9μ; but one spore in the same perithecium was 28 × 12μ. The identification of the specimen on *Asterolecanium* as *Sphaerostilbe coccidophthora* is therefore probably correct.

Sphaerostilbe aurantiicola (B. & Br.) Petch has been received from Madagascar, *per* Mr E. E. Green, on *Lepidosaphes* on *Citrus*; and from New Guinea (New Ireland), coll. Dr G. Bryce, on a scale on *Hibiscus*.

COCCIDOPHTHORA.

In *Annales Mycologici*, XI (1913), p. 263, H. and P. Sydow instituted a new genus, *Coccidophthora*, for a fungus on a scale insect on *Sasa paniculata* which had been sent from Japan by K. Hara. The fungus covered the insect with a stroma, which bore densely-clustered, globoso-conoid or irregular, black perithecia, either superficial or slightly immersed, with oblong, three-septate, brown ascospores, 8–11 × 3–4·5μ.

After describing the type species, *Coccidophthora variabilis*, the authors stated that the stroma consisted of hyaline to brownish-olive hyphae, which became darker and thicker from the base upwards. Among the black perithecia there occurred cinnabar-red perithecia without spores of any kind, and these were considered to be doubtless immature perithecia of the same fungus which would become darker later.

In the following year (*Bot. Magazine*, Tokyo, XXVIII (1914), pp. 339–51, Japanese section) Hara stated that the specimens submitted to Sydow were a mixture of two fungi, a stromatic *Nectria* parasitic on the scale insect, and black perithecia of another fungus, destitute of a stroma, parasitic on the *Nectria*. This would explain why *Coccidophthora variabilis* had red perithecia among the black ones. That the stroma of the *Nectria*

was completely blackened by the parasite is parallel to the action of *Sirosperma* and *Sirosphaera*, black pycnidial fungi, on the stromata of *Aegerita Webberi*, *Hypocrella* spp., and *Nectria diploa*. There does not seem to be any doubt as to the correctness of Hara's conclusions in this respect.

Hara named the Nectria, *Nectria variabilis*, but from his figures and description it was clearly *Nectria diploa* B. & C. He also instituted a new genus, *Philonectria*, for the super-parasite, which he named *Philonectria variabilis*.

The generic characters of *Philonectria* are as follows: Parasitic on other fungi: stroma none; perithecia caespitose, globose or elliptical, carbonaceous or carinous (*sic*), membranaceous, black, ostiolum papillate. Asci cylindrico-clavate, eight-spored, paraphysate, spores elliptic or fusiform, three-septate, coloured.

The type species, *P. variabilis* had spherical or subglobose, smooth, black perithecia, 250–300μ high, 220–260μ diameter, with a papillate ostiolum; asci cylindrico-clavate or lanceolate, stipitate, 80–96 × 6–9μ; paraphyses filiform, hyaline, 1–1·5μ diameter; spores elliptic or fusiform, three-septate, not or slightly constricted, yellowish-brown, 10–13 × 4–5μ.

Sydow stated that the perithecia had very minute papillate ostiola, which were often scarcely discernible, and that the asci were very shortly stalked or subsessile. The dimensions were, perithecia, 150–360μ high, 120–200μ broad; asci, 80–100 × 6–9μ; spores 8–11 × 3–4·5μ.

The characters assigned to the genus *Philonectria* do not appear to justify the institution of a new genus.

In February 1923, specimens of a *Hypocrella* were collected at Hakgala, Ceylon, on *Microtropis Wallichiana*. These were parasitised by *Sirosperma Hypocrellae*, and on microscopic examination it was found that perithecia were present with the *Sirosperma* pycnidia. The two occur intermingled, forming a continuous layer over the *Hypocrella* on a scanty byssoid stroma, the hyphae of which extend laterally over the surface of the leaf, surrounding the *Hypocrella* stroma with a black, byssoid, circular patch. These repent hyphae are regular, 3–4μ diameter, greenish olivaceous, uniting laterally into strands. Immature perithecia or pycnidia are situated on the byssoid patch, and in one specimen, erect rigid hyphae, 1·5–2μ diameter, pale brown and closely verrucose, arise from the byssoid patch, but with no necessary relation to the developing perithecia. In a second specimen these erect hyphae are lacking.

The perithecia on the *Hypocrella* stroma are superficial, black, rugose, 75μ diameter, subglobose, ostiolate, the ostiolum not elevated; the wall is thick, parenchymatous, greenish fuscous when mounted; the asci are clavate, thick-walled, eight-spored,

36–40 × 10–12μ, with biseriate spores; paraphyses were not observed; the spores are brown, fusoid or oblong, ends obtuse, three-septate, a few not constricted, but most constricted at all the septa, or strongly constricted at the median septum only, 9–12 × 3–4μ.

This species agrees with *Philonectria variabilis* in the size of its ascospores; some of the ascospores are not constricted and match Sydow's figures, but the majority are strongly constricted. It differs in the smaller perithecia and asci. Paraphyses were not observed, but it is possible that these are evanescent.

The type specimen of *Aschersonia Tamurai* from Japan contains some old black examples, in addition to the normal orange or pale yellow stromata. On a re-examination of a slide of a black specimen, it was found that the colour is due to the presence of *Philonectria variabilis*. The perithecia vary from globoso-conoid, 125μ high, 110μ diameter, with a broad papillate ostiolum, to flattened globose, 125μ diameter, without an elevated ostiolum. They are crowded on the *Aschersonia* stroma, either superficial or embedded up to the ostiolum, or scattered over the hypothallus. A few bear two or three stout, dark brown, obtuse setae, 22–32μ high, 6μ diameter, near the apex. The majority of the perithecia are effete, but mature ascospores occur free in some. These are the same shape as those of the Ceylon specimen, but larger, 14–18 × 4–6μ. The *Aschersonia* stroma is permeated by the olivaceous hyphae of the superparasite.

The Ceylon species appears to be identical with that from Japan. Consequently, *Philonectria variabilis* is the perithecial stage of *Sirosperma Hypocrellae*. The latter occurs commonly on *Nectria diploa* B. & C. But this perithecial stage would appear to fit well in *Melanomma*, according to the interpretation of that genus which has hitherto been current. In that case it will stand as *Melanomma variabilis*.

SPHAERIOIDACEAE.

The following pycnidial fungi have been found on scale insects, apparently independent of any other fungus. It is probable that these are parasitic on the insects.

ERIOTHYRIUM COCCICOLUM n.sp. Mycelium irregular, fuscous, 2μ diameter, spreading over the scale. Pycnidia superficial, flattened convex, circular or oval, about 110μ diameter, scutate, distinctly ostiolate, cover netted, somewhat, but not markedly, radial; pycnospores minute, hyaline, oblong-oval, 1·5 × 0·75μ, or subglobose, 1μ diameter. On *Lepidosaphes* sp. on *Murraya exotica* L., Peradeniya, August 1913.

PYRENOCHAETA SPARSIBARBA n.sp. Mycelium forming a compact black stroma round or over the insect and spreading in fine strands over the leaf. Pycnidia superficial on the stroma, clustered, globose, black, 80μ diameter, not ostiolate, bearing scattered, rigid setae; wall parenchymatous, black or blackish-green; setae conical, up to 36μ high, 5μ diameter below; pycnospores hyaline, oval, 2–3 × 1–1·5μ. On *Fiorinia juniperi* Leon. on *Juniperus bermudiana* L., Peradeniya, December 1923.

MURICULARIA CALVA n.sp. Pycnidia arising from a parenchymatous stroma at the margin of, or on a thin byssoid stroma over, the scale, clustered, black, ovoid, rugose, up to 150μ high, 120μ diameter, not ostiolate; wall parenchymatous, opaque, structure obscure; pycnospores tetrahedral, triangular in plan, with rounded angles and concave sides, 2μ along each side. On *Fiorinia juniperi* on *Juniperus bermudiana* L., Peradeniya, December 1923.

The conidia agree exactly with the triangular conidium figured for *Muricularia eurotioides* Sacc., but the pycnidium is not thorny.

In *Ann. Perad.* VII (1921), pp. 246–7, a purple, imperfectly developed form of *Aschersonia placenta* was recorded from Sigiriya, Ceylon, and it was suggested that the peculiarities of the stromata were caused by a super-parasitic fungus. A re-examination of this collection has shown that some of these abnormal stromata bear pycnidia of a *Coniothyrium*.

THE MARKET FUNGI OF JAPAN.

By Shigenori Kawagoe.

THERE are many species of delicious edible fungi in Japan. Some of them are popular and very important economically throughout the whole empire, others are sold in some local markets only, and some are not handled at all by the shops.

Here I will relate about some of the most significant and interesting edible fungi sold in the Japanese markets.

Cortinellus edodes P. Henn. (*Armillaria edodes* Berk.). The Japanese name is "Matsu-dake," meaning "Pine-mushroom."

This mushroom is limited to the groves of *Pinus densiflora* Sieb. & Zucc., of which the Japanese name is "Aka-matsu," meaning "Red pine." The mycelium lives with the rootlets of this species of *Pinus*, forming mycorrhiza, and never associated with other species of *Pinus* or other trees, except, in very rare

cases, it grows with *Tsuga Sieboldii* Carr. The "matsu-dake" has a peculiar aroma and a very agreeable flavour, derived from the pine tree, with which it lives. The "matsu-dake" is esteemed as the king of the Japanese edible fungi. The growing season of the "matsu-dake" is usually from the middle of October to the beginning of November, but occasionally it grows in the rainy days of May and June; in the latter case the flavour of the mushroom is inferior and it is then esteemed merely by reason of being a rarity or out of season. "Pine-mushroom hunting" ("Matsu-dake gari") is one of the annual outings of the people living in the cities and towns of the "red-pine-grove regions," for aristocrats as well as for commoners, from ancient times to the present day. Just before the beginning of the "matsu-dake" season many local men, as agents, get the right to manage the pine groves in which the mushroom grows, by paying rent to the owners or the local forestry officials, according to whether the groves belong to private persons or are State Forests. The agent, who is called "yama-ban" (meaning mountain guard), encloses his area and divides it into several parts with rice-straw rope. The price of admission varies according to the magnitude of the area and the estimated amount of the mushroom growing in the enclosure. Many picnic parties, consisting of a single, two or more families, or members of societies, or employees of companies or factories, rush to the "matsu-dake" hills, and enter the enclosures after paying the admission fee to the agents. The parties take with them provisions consisting of rice, fish or meat, vegetables, "sho-yu" (a kind of sauce made of soya-beans, barley and malted rice), "saké" (an alcoholic drink made of rice) and others. After gathering mushrooms they cook or roast part of them with the provisions they have brought, enjoy a very pleasant lunch and take the other part of the crop to their homes. "Matsu-dake" hunting is not so easy, because young mushrooms are usually covered with leaf mould and even mature ones are apt to escape the sight by the similarity of the colour of the pileus to that of leaf mould, so the pleasure and delight in the discovery of the mushroom is the greater. Some people can find the mushroom by the scent. "Matsu-dake" hunting is one of the most remarkable customs in Japan, and it is cited very often in poetry and fine arts. The "matsu-dake" is appreciated not only by picnic parties, but it is gathered by commission merchants and distributed to green-groceries in various parts of Japan. By the advantage of quick railway service, people living away from the red-pine regions can enjoy the delicious taste of a fresh "matsu-dake." The young "matsu-dake" is cooked and canned on quite a large scale, and distributed to groceries; by this means people can

eat "matsu-dake" at any season, but, of course, the canned "matsu-dake" cannot rival the fresh one in its flavour.

Cortinellus Shiitake P. Henn. (*Collybia Shiitake* Schroet.; *Lepiota Shiitake* Tanaka).

The Japanese name is "Shii-take"; "shii" is the name of a Fagaceous tree, *Pasania cuspidata* Oerst., "take" means a mushroom. This mushroom is saprophytic on dead woods of various species of *Quercus*, *Pasania* and other allied Fagaceous trees. It grows spontaneously in the forests of the warmer parts of Japan, but owing to the great demand people cultivate it artificially or help its natural growth. The "shii-take" is highly esteemed when fresh, but that is limited to the districts which produce it and the fresh mushroom seldom appears in the market. Almost all the production of "shii-take" is dried, usually by air, but sometimes artificial heat is applied. When the "shii-take" is dry, a characteristic aroma and a peculiar sweetish taste are produced, which do not exist when it is fresh. The dried "shii-take" is not only delicious itself, but it imparts a specially nice flavour to soup and other foods. It is consumed quite abundantly by Japanese, but is exported in great quantities to China; the dried "shii-take" is indispensable in Chinese cooking. It is one of the leading exports and one of the most important products of Japan. In nature the "shii-take" grows on decayed parts or on quite dead trunks of Fagaceous trees, but the "shii-take" growers make special substrata for culture of the mushroom. They arrange and pile up the trunks of Fagaceous trees, mostly some species of *Quercus*, in shady and properly moist places in forests. The trunks used as the substrata are called "hoda-gi." The "shii-take" growers inoculate the trunks with either the spores or the mycelia. In the former case they pour the mixture of the smashed mature mushroom and water on the incised surface of the trunks, then they cover the inoculated trunks with wet straw mats to keep them moist. Thus the spores germinate and the mycelia penetrate into the wood of the "hoda-gi." In the case of the mycelium inoculation, they carve off the surface of the "hoda-gi" in several spots and fill the holes with the blocks cut from old wood which is impregnated with the mycelium of "shii-take," and keep it moist as in the former case; then the mycelium spreads and penetrates into the wood of the new "hoda-gi." Thus the "shii-take" growers can get crops from the same "hoda-gi's" for a considerable number of years.

Rhizopogon rubescens Tul. (*R. virescens* Karst.; *R. aestivus* Schroet.). The Japanese name is "Shoh-ro"—"shoh" means pine tree, "ro" means dew drops. This globular and subterranean fungus grows under pine trees—mostly *Pinus Thunbergii*

Parl.—in the sandy soil of a sea shore or a river bank. It is very likely that the mycelium of this fungus may live with pine roots as mycorrhiza, just like the case of *Cortinellus edodes* and *Pinus densiflora*, but the biology of this fungus is not yet investigated. The "shoh-ro" hunting on a pine-clad sandy beach is a very pleasant amusement. When the sand under the pine grove is dug out with a bamboo-rake, the curious fungus just like a miniature potato tuber is found. The "shoh-ro" is not so popular as the "matsu-dake" or the "shii-take," because the supply is not so abundant. Owing, however, to the nobility of its flavour it is much esteemed as a material for soup in a high-class dinner, just like the European truffle. Recently the canning of the "shoh-ro" has become popular, and we find the canned "shoh-ro" in some groceries of the big towns, and in the cookeries of some passenger ships on long voyages, where it is kept together with cans of the "matsu-dake" and vegetables.

Phaeodon aspratus P. Henn. (*Hydnum aspratum* Berk.). The Japanese name is "Kawa-take" or "Koh-take," meaning "leather-mushroom." This is one of the common fungi sold in the Japanese groceries. It grows naturally on the humus soil in the forest. It is never used fresh. When it is dried it emits a sweetish aroma so strong that when a single mushroom is put in a room the air becomes impregnated with its odour. The dried "koh-take" looks like a piece of brownish-black leather; so the Japanese name is derived. The "koh-take" is cooked with "shoh-yu" (soya-bean sauce), sugar, and sometimes "mirin" or "saké" (the latter two being alcoholic drinks made of rice), and used as a part of dishes in a rich dinner.

Auricularia auricula-Judae Shroet. (*Hirneola auricula-Judae* Berk.). The Japanese name is "Ki-kurage"—"ki" means tree, "kurage" means a medusa or jelly-fish. As for this cosmopolitan fungus, I think there is no necessity to explain its character and habits; it grows saprophytically on almost any kind of tree, in garden, orchard, park, street, field, forest—everywhere. People do not cultivate the "ki-kurage," but just gather the natural production. We can find the dried "ki-kurage" in any groceries. The "ki-kurage" has practically neither taste nor flavour, but when it is mixed in other foods, it gives a peculiarly agreeable tactile sense in the mastication. The amount of Japanese "ki-kurage" exported to China is greater than that consumed in Japan.

There are many other market fungi in Japan, but they are rather local, so I will cite here only a few of the most interesting ones among them.

Tricholoma bicolor P. Henn. (*T. personatum* Fr.; *Agaricus bicolor* Pers.). The Japanese name is "Murasaki-shimeji" or

simply "shimeji." This mushroom is so much esteemed that there is a proverb, "Nioi matsu-dake, aji shimeji" (meaning "in flavour, the matsu-dake is superior; but in taste, the shimeji is superior). As the supply is scarce the market price of the "shimeji" is much higher than that of the "matsu-dake." The "shimeji" is cooked fresh.

Collybia velutipes Karst. (*Agaricus velutipes* Curt.; *A. austriacus* Tratt.; *A. Aesculi* Schum.; *A. nigripes* Bull.). The Japanese name is "Yenoki-take"—"yenoki" is the name of a tree, *Celtis sinensis* Pers., on which the mushroom grows saprophytically. This stalkless mushroom is esteemed because it grows in the early spring when other kinds of edible mushrooms do not grow. People peel the cortical layer of the pileus before cooking, because it is comparatively tough.

Polyporus frondosus Fr. The Japanese name is "Mai-take," meaning "dancing mushroom," the beautiful and large fruiting body with many lamellate lobes is metaphored to dancing girls waving their hands and kimono-sleeves. The "mai-take" is cooked fresh, or preserved in salt. In the latter case it is soaked in water before cooking to remove the salt.

Lactarius Hatustake Tanaka. The Japanese name is "Hatsu-take," meaning "the forerunning mushroom," because it grows prior to other mushrooms in the early autumn.

Lactarius Akahatsu Tanaka. The Japanese name is "Aka-hatsu," being the abbreviation of "aka-hatsu-take," meaning "the reddish forerunning mushroom."

The above two species of *Lacturius* grow usually on lawns composed of a grass, *Zoysia pungens* Willd. var. *japonica* Hack. The former is dirty brownish coloured, and the latter bright reddish yellow brown. They are used fresh.

Ustilago esculenta P. Henn. I cannot omit this very interesting fungus sold in the markets of Tai-wan (Formosa). The Chinese name is "Kah-peh-sŏŏn," meaning "white bamboo-shoot growing on the wild rice plant" (*Zizania aquatica* L.). The "kah-peh-sŏŏn" is the hypertrophied sprouts of *Zizania aquatica* L. (*Z. latifolia* Turcz.), filled with the mass of the sporogenous hyphae of a smut-fungus, *Ustilago esculenta* P. Henn. It has been much esteemed by Chinese races in Formosa since olden times. *Zizania aquatica* L. is a common wild grass in Taiwan as well as in the main islands of Japan, but in Taiwan it is cultivated on road-sides or in back yards in the country for the purpose of "kah-peh-sŏŏn" growing. If once a *Zizania* plant is affected by *Ustilago esculenta* the mycelium of the parasite is perennial within the rhizomes of the host plant and the fungus forms its chlamydospores in the deformed buds (not in the inflorescences) every year. So people select the affected plants for culture and

throw away the healthy plants as useless. Before the maturity of the chlamydospores, the mass of hyphae is snow-white and very compact; the fungus at such a stage of development is in the best condition for eating, so it is gathered just at this stage and sold in market at a good price. The Japanese people in Taiwan are also fond of it. When the spores begin to mature many black tubercles appear gradually in the white mass, then it can no more be dealt with as a market vegetable; finally the abnormal sprout is filled with a mass of black powder. This smut fungus exists also in the main islands of Japan, but Japanese people had no experience in eating it before the possession of Taiwan. In the main islands the sprouts of *Zizania* deformed by the smut are not so large as in Taiwan. The mature chlamydospores are called "Makomo-zumi"—"makomo" is the Japanese name for *Zizania aquatica*; "zumi" or "sumi" means ink or black dye. Formerly the "makomo-zumi" was sold by druggists and was used to paint eyebrows and borders of the hair by ladies or actors and sometimes used as medicine.

Umbilicaria esculenta Mink. (*Gyrophora esculenta* Miyoshi.). The Japanese name is "Iwa-take," meaning "rock-mushroom." This is not a fungus but a gelatinous lichen. But I cannot bear to omit here this interesting fungus-ally. This lichen usually grows on rocks forming dangerous cliffs, so sometimes the "iwa-take" hunters risk their lives. In some cases the hunter gets in a basket which is hung down from the top of the cliff, and gathers the lichen growing on the rocks, then, after the collection, he is pulled up to the top or put down to the bottom of the cliff. The occurrence of the "iwa-take" is very local, mostly growing in places difficult of access, in the heart of mountains. Consequently the market price is very high and the lichen is used just as a dainty in a high-class dinner. The thallus of the "iwa-take" is flat and roundish with undulate margin, in average 3–5 inches in diameter, blackish, smooth on the upper surface and fluffy on the under surface, about the centre of which there is an umbilicus or navel, with which the thallus adheres to the substratum, the rock. Like other gelatinous lichens it becomes brittle in dry weather, and gelatinous in the wet.

The common mushroom, *Psalliota campestris* Schroet. (*Agaricus campestris* L.), so popular in Europe and America, grows wild in Japan, but it is not sold in the markets.

AN INVESTIGATION OF THE HYMENIUM OF THREE SPECIES OF STEREUM.

(With 9 Text-figs.)

By A. W. Exell, B.A.

As there are apparently no accurate descriptions or figures of the hymenial structure of some of the commonest species of *Stereum*, the present work was undertaken at the suggestion of Mr F. T. Brooks.

Sections of the fructifications of the three species examined show three layers: (1) the hymenium, on the outer surface of a resupinate fructification or on the lower surface of an imbricate one; (2) the so-called intermediate or middle layer of irregularly arranged hyphae; (3) a layer of thick-walled hyphae, the subiculum, basal when the fructifications are resupinate and forming the upper surface when they are imbricate. Sometimes these layers have no very definite boundaries.

Stereum purpureum (Pers.) Fr.

Hymenium. The hyphae forming the hymenium are arranged in a parallel manner, vertical to the surface of the fructification. Branching occurs regularly in the hymenium but no septa can be distinguished in this region. There is complete absence of paraphyses and every hypha appears to be a potential basidium though it may never develop as such.

In the formation of a basidium the tip of a hypha at the surface of the hymenium becomes swollen and eventually projects beyond the surface to a greater or less extent (up to 6μ including the sterigmata). Four sterigmata are produced, the basidia being 4–5 × 4μ and the sterigmata 2–3μ.

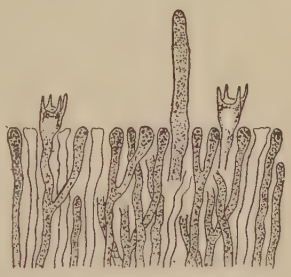

Fig. 1. *Stereum purpureum.* Section of hymenium showing basidia, colourless hyphae and a hymenial cystidium. × 500.

The hyphae forming the hymenium and particularly the young basidia, stain deeply with iron alum-haematoxylin, gentian violet, etc. A large vacuole forms in the mature basidium and after the spores have been shed an empty colourless structure, with sterigmata still visible, remains projecting from the surface of the hymenium. These empty basidia may be noticed in all stages of collapse until they no longer project. Numbers of empty colourless hyphae, which originally bore basidia, are apparent in

old fructifications but are entirely absent from young hymenia in which the first basidia are forming, so that it is unlikely that any of these colourless structures can be regarded as paraphyses (fig. 1).

The structures known as hymenial and sub-hymenial cystidia will be described later.

Intermediate layer. This consists of branched hyphae, 1–1·5μ in diameter, running quite irregularly in every direction. Here and there short lengths of larger, deeply staining hyphae 2–3μ in diameter, can be made out; but the irregular arrangement of the hyphae makes it extremely difficult to decide to what extent they form a connected system.

Subiculum. This consists of thick-walled hyphae 3μ in diameter and is a well-marked layer in this species.

Cystidia. The term cystidium has been applied to very various organs in Fungi. Thus Buller (1) says: "Cystidia, like paraphyses, are sterile elements, but they differ from these in their larger size, their peculiar form, their smaller number, and frequently in the nature of their cell walls and of their contents. They are present in some species but not in others. In some species where they occur, but not in all, they produce characteristic excretions, while in certain Coprini they have a mechanical function." Buller (2) has also adopted a topographical system of nomenclature for the cystidia found in many Agaricineae. It would seem advisable to make a clear distinction between these structures and the cystidia of genera such as *Stereum* and *Corticium*, which appear to have a very different function.

The pyriform swellings in *Stereum purpureum*, which have since been called "vesicular organs," Burt (3), and "subhymenial cystidia," Rea (4), were first described by Istvánffi (5) in an account of the conducting systems of various Hymenomycetes. Describing *Stereum purpureum* he states: "Die Leitungselemente bilden hier runde, mit einem langen Stiel versehene Zellen, die in sehr grosser Anzahl auftretend, die obere Hälfte des Fruchtkörpers oft ganz ausfüllen." His "obere Hälfte des Fruchtkörpers" is really the lower half of a normally oriented imbricate fructification.

At the surface, just behind the growing region of a fructification, where the hymenium is just forming, numbers of these vesicular bodies are to be found (fig. 2). When the hymenium grows they are left behind in the typical position just at the base of the hymenium (fig. 3). They stain deeply and are conspicuous objects 9–18 × 6–10·5μ in size. Microtome sections show that, at this stage, they are contained in cavities which are probably full of liquid, as hand-sections of fresh material show no traces of air-bubbles in this region. The vesicular bodies

Fig. 2. *S. purpureum.* Vesicular bodies in growing region of fructification. × 500.

Fig. 3. *S. purpureum.* Section of hymenium showing vesicular bodies, one of which has collapsed. × 500

eventually lose their contents and remain as empty, colourless structures. Fixed material seemed to show that they actually burst but there is no evidence as to whether this occurs in natural conditions. As the fructification becomes older more vesicular bodies are formed in the intermediate region until there may be many layers of them. When they have become empty and disappeared, their cavities remain; so that a section of an old fructification may show numerous holes, giving the subhymenial region a perforated appearance (fig. 4).

The vesicular bodies may also occur in the hymenium and

Fig. 4. *S. purpureum.* Section of hymenium of old fructification showing the series of holes left by the collapse of the vesicular bodies. ×250.

Fig. 5. *S. purpureum.* Vesicular bodies which have budded out. ×500.

occasionally at its surface, so that the term subhymenial cystidia, while describing their usual position, is not entirely accurate.

The hyphae which produce these structures are 3–4μ in diameter, and it is found that locally at least they form a connected system. It is difficult to make out to what extent this system remains independent throughout the fructification, but the occasional deeply-staining hyphae found in the intermediate layer may form a "laticiferous" system of which the vesicular bodies are the terminations.

Occasionally the vesicular bodies may bud out to form others of similar appearance (fig. 5).

The contents of the vesicular bodies stain very deeply with iron alum-haematoxylin, Sudan III, Scharlach R, osmic acid and cotton blue. This occurs with both fresh and fixed material. After treatment with acetone, ethyl ether, or chloroform the sections still stain in the same manner so that it is unlikely that the substance which stains is a fat or oil. Very tiny droplets present in all the hyphae of the fructification stain in the same way and this makes the material unfavourable for cytological investigation.

An interesting comparison can be made with the similar swellings which occur in *Russula*. Maire(6) states that "Elles sont quelquefois, mais pas toujours, en connexion avec les laticifères quand il en existe dans la lamelle"; and later: "D'abord à peine granuleux et incolore leur contenu se charge de gouttelettes oléagineuses souvent jaunâtres, puis au début de la sporulation on voit ces gouttelettes s'émulsionner et disparaître. La cystide a alors terminé son rôle de cellule sécrétrice et elle devient excrétrice; son contenu se charge souvent de cristaux et parfois sa membrane s'incruste extérieurement." It may be mentioned that in sections of a very old specimen of *Stereum purpureum* one or two crystals were present in the subhymenial region at about the level formerly occupied by the vesicular bodies.

Burt (*loc. cit.*) has distinguished between the two species *Stereum purpureum* (Pers.) Fr. and *Stereum rugosiusculum* Berk. & Curt. mainly on the absence of *hymenial cystidia* in the former and their presence in the latter. These he describes as "slender, thin-walled, tapering hairs, not incrusted, 4–5μ in diameter, protruding up to 25μ beyond the basidia," and later, "it [*Stereum rugosiusculum*] is distinguishable from the latter [*Stereum purpureum*] only by the presence of weak flexuous hairs in the hymenium which are not visible until sectional preparations are examined with the compound microscope." He also states that he had not examined a specimen throughout its whole season of growth to determine whether the hair-like cystidia are a constant character.

Brooks(7) has pointed out that the possession of hymenial cystidia is a variable feature, that there is every stage between forms possessing many and forms devoid of them, and that the separation into two species on this character is not valid. In all the specimens examined during the present investigation, hymenial cystidia were infrequent. In many sections none were present, but three or four examples were to be found on almost any slide of a dozen or more sections, and sometimes they were as frequent as three or four to a section. They project 12–24μ from the hymenium and are 3–4μ in diameter. Burt (*loc. cit.*)

gives the dimensions 4–5μ in diameter and protruding 25μ beyond the basidia. His figure is not very clear but there seems little doubt that these are the same structures.

The typical form of a hymenial cystidium is shown in fig. 1.

Occasionally the hymenial cystidia are found to be considerably swollen at the surface level of the hymenium so as to resemble closely the vesicular bodies or subhymenial cystidia (fig. 6). As quite typical examples of the latter are frequently found in the hymenium, sometimes right at the surface and occasionally even projecting beyond (fig. 7), it appears that the so-called hymenial and sub-hymenial cystidia are one and the

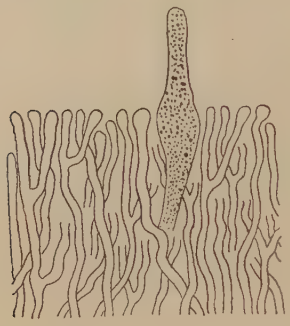

Fig. 6. *S. purpureum.* Hymenial cystidium swollen at the level of the hymenium. ×500.

Fig. 7. *S. purpureum.* Vesicular bodies, one at the surface of and one projecting from the hymenium.

same thing and that they are merely so-named according to position. If this be true, the hymenial cystidia are conducting hyphae which, failing to enlarge and form the usual vesicular bodies, have grown beyond the surface of the hymenium. They have protoplasmic contents and are not empty hairs.

Formation of successive spore deposits. It is well known that a fructification of *Stereum purpureum* may be allowed to dry up until quite hard and brittle and that, on being moistened a spore deposit is soon formed. When moist the fructification is of a consistency something like rubber. In sections stained with congo red the hyphae appear to be embedded in a transparent jelly which takes the stain very faintly. It can best be seen by examining the surface of the hymenium or the edge of the holes containing the vesicular bodies.

When pieces of fructifications which have been kept dry for several months are moistened, a spore deposit will form under favourable conditions within four to six hours. Pieces of material were fixed at intervals of an hour after moistening the

fructification. These preparations show that it is not necessary for a new hymenium to form, or for new basidia to push their way through the old hymenium. Basidia actually projecting above the surface before drying, become shrivelled; but pieces of material fixed ten minutes after moistening show tips of hyphae full of protoplasmic contents only 2–3μ from the surface. Within four hours these are able to form basidia. Thus, despite the shrivelled appearance of the fructifications in hot weather, they would presumably be producing spores in four hours after a heavy shower of rain. By successive dryings and moistenings one piece of fructification formed nine spore deposits. It is suggested that the vesicular bodies contain stores of food substances which allow of this rapid production of basidia and the formation of so many spore deposits, in rapid succession, from one hymenium. This may be a factor in the success of *Stereum purpureum* as a parasite.

Material gathered October 30, 1923, formed spore deposits up to March 12, 1924. In dried material gathered January 16, 1924, and fixed February 7, 1924, after moistening for ten minutes, the vesicular bodies were full of contents and were indistinguishable in appearance from those of fresh material.

Fructifications in Artificial Culture. Sections of rudimentary fructifications formed in artificial culture* showed a loose arrangement of basidia on the surface without any definite hymenium. There were no vesicular bodies nor cystidia of any kind.

It may be mentioned that the presence of the vesicular bodies, or, in very old material the holes left after their disappearance, is a useful means of identification of doubtful specimens.

Stereum hirsutum (Willd.) Fr.

Burt (*loc. cit.*) describes the fructification as follows: "...in structure 500–700μ thick under the hairy covering, with the intermediate layer bordered next to the hairy covering by a very dense, narrow, golden-yellow zone, the rest of the intermediate layer composed of densely and longitudinally-arranged hyphae 3–4μ in diameter, some of which in the sub-hymenium are thick-walled up to 5–6μ in diameter, and very rarely have golden-brown contents as seen between the basidia; no coloured conducting organs, cystidia nor gloeocystidia."

Microtome sections confirm this description. In stained sections the thick-walled hyphae are very conspicuous, running up into the hymenium without branching and with occasional septa. The thickness of the walls is such that the cavity of the

* I am indebted to Mr J. K. Mayo, B.A., for this material.

hypha is often very narrow. These hyphae are identical with those forming the tough, upper layer of the fructification, or dense, narrow, golden-yellow zone described by Burt, and they can sometimes be traced running from this layer, right through the intermediate layer, to the surface of the hymenium. Sometimes they project slightly beyond the surface (fig. 8). The thin-walled hyphae forming the mass of the intermediate layer are 3–4μ in diameter and frequently septate, while those of the hymenium are 1·5μ in diameter and apparently devoid of septa.

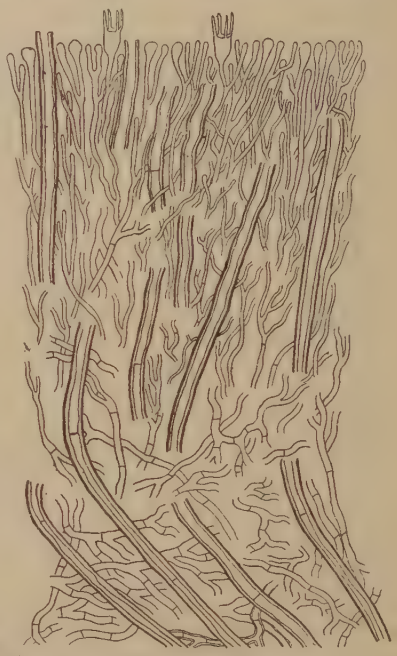

Fig. 8. *S. hirsutum.* Section of hymenium showing thick-walled hyphae. × 350.

The hymenium of *Stereum hirsutum* was described and figured by Istvánffi (*loc. cit.*), but he classes the thick-walled hyphae in the hymenium and intermediate layer as conducting organs such as those of *Stereum sanguinolentum* and does not mention the great thickness of the walls.

Marshall Ward (8) described and figured microtome sections of fructifications of *S. hirsutum* which had arisen in artificial culture. He found no thick-walled hyphae but there were two kinds of hyphae in the subhymenial region, one of which stained more deeply than the other (fig. 7, pl. 18, *loc. cit.*). This may correspond with the thick-walled system in the natural fructifications. He also mentions and figures (fig. 6, pl. 18, *loc. cit.*) pyriform swellings which occurred at the base of the fructifications. These were not recognisable in sections of natural fructifications.

Thus *S. purpureum* and *S. hirsutum* show considerable differences between fructifications formed under natural conditions and those formed in artificial culture. Some of these differences may be due to the fact that the latter are formed in a saturated atmosphere.

As in *S. purpureum,* successive spore deposits may be formed and a fructification which has been dried for months will form a spore deposit within a few hours.

Stereum sanguinolentum (A. & S.) Fr.

In a fresh state the hymenial surface of this species bleeds when wounded owing to the escape of a blood-red liquid contained in conducting hyphae. The liquid rapidly turns brown on exposure to the air.

Istvánffi gives figures of the conducting hyphae (fig. 7, pl. 4) and an accurate description of their distribution. They are slightly thick-walled, and old ones, whose contents have escaped, remain as colourless elements in the hymenium (fig. 9).

Fig. 9. *S. sanguinolentum.* Section of hymenium showing conducting organs, many of which are empty. × 500.

Artificial cultures of this species made on twigs of *Pinus sylvestris* and *Larix europaea* did not produce any fructifications though solid lumps were formed on the mycelium. Sections of these showed no basidia and no trace of conducting organs.

Method. The material was fixed in chromacetic solution and taken up to paraffin wax through cedar-wood oil. Sections were cut at 4μ and 6μ. Unless otherwise stated they were stained with iron alum-haematoxylin.

I wish to express my sincere thanks to Mr F. T. Brooks for his help and advice throughout this work.

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THE STRUCTURE AND DEVELOPMENT OF TWO NEW ZEALAND SPECIES OF SECOTIUM.

(With Plates XI and XII.)

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In the course of a revision of the Australian and New Zealand species of the genus *Secotium* (1924) the writer was somewhat doubtful as to the position this genus should occupy among the Gasteromycetes. The earlier taxonomists placed it in the tribe Podaxineae of the family Lycoperdaceae, a classification generally followed; Fischer (1900) proposed the family Secotiaceae to include it and three other genera, and more recently, Conard (1915), as a result of the study of the development of *S. agaricoides* (Czern.) Hollós, has suggested that it should be placed in the Agaricaceae. As *S. agaricoides* is a somewhat aberrant species of the genus, and as several of Conard's conclusions are at variance with ideas held by the writer, a search was made for developmental stages of two of our most common species. By thoroughly working out the development of these two species, it was hoped that some light might be shed on the taxonomic position of the genus.

Two species were chosen, one, *Secotium erythrocephalum* Tul. being typical of the genus as now defined, the other, *S. novae-zelandiae* G. H. Cunn. (*loc. cit.*, p. 11) being, in the structure of the mature plant, intermediate in position between *S. erythrocephalum* and *S. agaricoides*.

Although the following details (with minor differences) are equally applicable to either species, *S. novae-zelandiae* is discussed at greater length, as more abundant developmental stages of this species were obtained.

The genus *Secotium* is characterised by the fact that the coriaceous peridium encloses a cellular gleba, and is borne on a definite central stipe which continues through the gleba as a columella and merges with the apex of the peridium. Dehiscence is supposed to be effected by the tearing apart of the margin of the peridium from the stipe, but as this does not expose more than a very minute portion of the hymenium, and as it very frequently does not occur at all in different plants of the same species (figs. 13, 18), it would appear that the plants may be more correctly considered to be indehiscent.

Secotium novae-zelandiae (fig. 5).

MATURE PLANT.

The *peridium* is usually ovate in shape, and may attain a size of 3–5 cm. high by 1·5–3 cm. broad. It is french-grey in colour, smooth, coriaceous and slightly viscid. It is about 3 mm. thick at the apex where it merges into the columella, tapering to the base where it is lacerate and somewhat folded. The folds are commonly decurrent and pressed to the stipe. Sometimes they are held in position by remnants of the partial veil. The peridium consists of a single layer, composed of closely-compacted hyphae, whose long axes are predominantly radial.

The *gleba* is sepia-coloured and is formed of numerous anastomosing tramal plates enclosing lacunae; these are either quite large and irregular in shape, the septa being gill-like, or else definitely cellular. Specimens with a gill-like gleba approach *S. agaricoides*, and those with a cellular gleba, *S. erythrocephalum*; but the prominent stipe, smooth cortex and large elliptical spores connect it with the latter species. Extreme types of this species, as well as intermediate connecting forms, may be collected from the same substratum, where they may appear growing side by side.

A tramal plate consists of the following three layers: (*a*) the trama, consisting of a central layer of septate hyphae arranged in a parallel manner, with the long axes of the cells parallel to the surface of the plate (fig. 1, *tr.*); (*b*) the subhymenium, a layer on either side of this consisting of numerous somewhat polygonal cells (fig. 1, *sub.*); and (*c*) the hymenium, an outer palisade layer of basidia, whose long axes are at right angles to the plate (fig. 1, *hy.*). On the basidia the spores, usually four in number, are borne on long and slender sterigmata. The spores are smooth, elliptic-ovate, and sepia in colour, the colour being confined to the wall. There are no paraphyses, cystidia or other aberrant cells.

The *stipe* is up to 4 cm. long, by 4–6 mm. thick, hollow, and somewhat fibrillose on the exterior; the base is attached to the substratum (decaying wood) by numerous yellow- or violet-tinted rhizoids. The stipe continues to the apex as the *columella* —the basal portion of which is free and surrounded by a narrow conical cavity, but its upper half is attached to the tramal plates of the gleba. No trabeculae are present. Spore dispersion is dependent upon the decay of the plant, or, as this species is readily eaten by slugs, it is probable that these animals serve in some manner to disseminate them.

Both this and the following species grow upon decaying wood; *S. novae-zelandiae* is confined to lowland rain-forest, but *S. erythrocephalum* is not uncommon in gardens, especially where the soil has been at one time in forest.

Development.

General.

In all some twenty-five developmental stages of this species have been collected; of these fourteen were sufficient to give a connected idea of development.

All were fixed in picro-formol (which gave the most satisfactory results of all the solutions tried), and stained with iron-alum haematoxylin, followed by 1 per cent. iodine-green in clove oil; this combination gave excellent results, much more satisfactory than numerous others that were experimented with.

As the plants are gregarious, it is not unusual to find many developmental stages attached to the same rhizoids on one piece of decaying wood. The young plants are first noticeable as small white swellings on the upper portion of a rhizoid, often close to a more mature plant. Sections show these to consist of closely-woven undifferentiated hyphae (fig. 6), exactly resembling in shape and size those constituting the rhizoid. The young plant begins to elongate, until it is about twice as long as broad, being at this stage about 2 × 1 mm. Then a small radial indentation appears on the exterior, marking off the peridium from the stipe; this is followed by somewhat rapid growth in diameter of the peridium, which gradually increases in size until it becomes two or three times the diameter of the stipe. The peridium also assumes a definite shape, for in quarter-grown specimens it has the form of the mature plant. It continues to enlarge until about three-fourths the size of the mature plant, when the stipe begins rapidly to elongate, carrying the mature peridium upwards until it stands some 25 mm. or more above the substratum. At first the young plant is dingy-grey, but when about one-third grown, the french-grey colour begins to appear in the peridium and stipe; and in old specimens the colour changes to cyano-blue or some shade of green.

Development of the peridium and gleba.

When the plants are about 2 mm. long sections show that differentiation of the peridium and stipe has commenced. The stipe is the first to become differentiated, and at this stage consists of hyphae arranged in parallel fashion, with their long axes parallel to the long axis of the plant. Near the apex these hyphae become merged with closely and intricately-woven hyphae, the primordium of the gleba and peridium. This area becomes further differentiated, and a ring of deeply-staining tissue appears near its base. It may be seen closely appressed to and completely surrounding the columella, which at this stage is well developed at the base, although it has not become

differentiated at the apex. There is as yet no indication of the presence of the peridium, nor is any universal veil present in this or any succeeding stage. In this deeply-staining ring a small radial lacuna appears, and below it, running downwards and outwards from the inner and lower margin of the columella to the margin of the apex of the stipe, appears a wedge-shaped radial ring of loosely-woven hyphae (fig. 7). This is the first appearance of the partial veil, the development of which is discussed in detail later. This lacuna, which extends in a ring around the base of the columella, enlarges, and the hyphae lining its roof become arranged in a palisade manner. These hyphae are thinner than those of the stipe, contain abundant protoplasmic contents, and are closely compacted together. At first they are confined to the roof, but soon extend around the walls until the whole cavity, with the exception of the basal portion, or floor, is lined with them. The cavity next alters in shape, becoming laterally compressed, and extends further into the upper part of the as yet undifferentiated portion of the gleba. Into it, downward growths of the palisade layer begin to penetrate (fig. 8); these grow until they come in contact with one of the lateral walls, with which they merge, thus dividing the original cavity into several smaller ones. At the same time further lacunae begin to form in the undifferentiated portion of the gleba immediately above the original cavity. Spores now appear on a few of the first formed palisade cells (fig. 9) not as yet differentiated into regular basidia, for no definite sterigmata are present, the spores being borne singly on terminal projections. Further septa continue to grow from the roof of the original cavity and merge with its side walls, and numerous lacunae are at this stage present in the upper portion of the peridium. These continue to form until the whole of the gleba is divided into numerous cellular areas. Basidia bearing the normal number (four) of spores now appear on the first-formed tissue. The lower portion of the gleba begins to separate from the base of the columella, and this continues until a small cavity, conical in shape, is formed around the lower half of the columella. Next, the peridium becomes differentiated; at first it is quite thick, save at its margin, but it soon becomes thinner, owing to the appearance of numerous lacunae in the hyphae bordering its inner surface. From this stage until maturity, development of the gleba consists in the formation of further lacunae in the thick tramal plates (figs. 11, 12).

These lacunae appear in the following manner: cells of certain hyphae in a definite area of the tramal plate become slightly inflated, and numerous septa appear in them; this is followed by the tearing apart of these hyphae so that a small cavity is

formed (fig. 12). This increases in size and the elements of the hymenium become differentiated, so that a portion of the original plate is split into two, and is consequently thinner than before. Increase in the surface of the plates occurs, and as a result the plates are thrown into numerous folds, which may at different points come in contact with other plates and anastomose. Fusion is effected as follows: the spores are first crowded to one side as the plates approach one another, then the basidia become somewhat compressed and crushed to one side; from the subhymenium small cells grow out and merge with those of the opposite plate.

Owing to the method of the formation of these lacunae the cavities in the mature plant are very numerous, and much smaller in size than in the young plant.

From the time plants are about half grown until they reach maturity spores are being produced in ever increasing numbers; indeed, so abundant is their production that small lacunae may be filled with them, and commonly they are two or more layers deep in all the lacunae of the mature plant.

Development of the stipe and columella.

The stipe becomes differentiated immediately before the primordium of the gleba. It then continues to grow until about the time of the formation of the first cavity of the gleba, when the cavity of the stipe makes its appearance (fig. 9). The stipe then makes little growth until the plant is about one-third grown, when it increases first in thickness, and then begins to elongate rapidly until it attains full size.

The columella is discernible immediately before the appearance of the first cavity, and extends for a short distance into the as yet undifferentiated gleba. It then continues to develop slowly until the time of the appearance of the first few septa in the glebal cavity, when it is seen to have extended almost to the apex of the peridium. It does not merge with the peridium until the plant is about half grown, for the latter structure is not discernible until the glebal cavities are somewhat numerous, being represented at first only by loosely-woven hyphae.

Development of the velum partiale and mode of "dehiscence."

The first indication of a partial veil has been previously discussed. It appears immediately after the first glebal cavity and may at this stage be seen as a wedge-shaped radial area running downwards and outwards from the base of the cavity to the outer and upper portion of the stipe. It is first noticeable owing to the presence of numerous air spaces between the hyphae of this region, these hyphae being more loosely woven than those

of the primordium of the gleba. These spaces gradually increase in size, and as the peridium and stipe develop, become separated more and more, in many cases being torn apart, until at maturity a few hyphae only are present, attaching the base of the peridium to the stipe. Once the partial veil becomes differentiated it would appear that little if any further growth takes place in this region, so that the separation of the hyphae and the appearance of the large air spaces results entirely through the further growth of the stipe and peridium.

Remnants of the veil persist on the periphery of the stipe and give to it a somewhat fibrillose appearance. These remnants are accounted for when the development of the stipe is considered, for when it is about 2 mm. long the partial veil is present, attached to and surrounding it throughout its length (fig. 9). As the stipe elongates, the fibrils of the partial veil are more and more widely separated until they are torn away from the upper points of attachment, when the remnants persist on the periphery of the stipe as the fibrils alluded to.

"Dehiscence" as a rule does not proceed further than this, for one frequently obtains mature plants in which the margin of the peridium is firmly united to the stipe by these remaining fibres of the partial veil.

Development of Secotium erythrocephalum.

Early stages of this species show characters similar to those of the preceding save that the first glebal cavity appears immediately before differentiation of the columella has begun. Later stages also are similar, save that the stipe becomes more thickened and does not elongate to the same extent (fig. 16); then, too, the lacunae appear more frequently and are much smaller in size, and the tramal plates are thinner.

The peridium early becomes covered with a definite gelatinous layer, formed of hyphae which have become gelatinised (fig. 17). The colour of the peridium appears when the plants are about one-quarter grown. The first few layers of the hyphae forming the peridium, underlying the gelatinous layer, become partially filled with granules of some pigment which readily take the haematoxylin stain. They appear to be imbedded in the protoplasm lining the hyphal walls, and become more plentiful as the plant approaches maturity. This layer is absent in the preceding species.

CYTOLOGY.

Cytological details appear to be the same in both species. The hyphae of the columella, stipe and peridium are invariably binucleate, the nuclei being close together and usually side by

side. Cells of the hyphae of these tissues are from 40–60μ long × 8–10μ thick; the basidia are 15–25 × 5–8μ. The basidia at first are binucleate; the two nuclei fuse, and a somewhat larger fusion nucleus is formed; this takes up a position near the free end of the basidium, and then divides twice, the first division preceding the formation of sterigmata, the second following their appearance. After the sterigmata have begun to elongate the spores appear, and are about half size when the sterigmata have attained their full size, 8–15μ. A nucleus migrates into each spore when they are about one-quarter size, for it is not present in spores smaller than this, although invariably present in spores that are larger (fig. 2). This nucleus divides mitotically when the spore is about half size, so the mature spore is binucleate (figs. 1, 2), a character difficult to determine, as at this stage the nucleus does not readily take the stain. The nuclei are highly refractive bodies, are exceedingly small, 2–5μ, and contain one large readily-staining nucleolus. The spore eventually attains full size, and begins to colour, becoming finally sepia, the colour being confined to the epispore.

Clamp connections are abundant in the tissues of the stipe and the hyphae constituting the partial veil (fig. 3).

The writer has grown specimens of *S. novae-zelandiae* on rotting twigs buried in leaf-mould in the laboratory, and finds that development is a slow process; from the time of the beginning of differentiation until maturity covers a period of from two to three months. Where insects are excluded the plant survives for at least a month after reaching full size, then it wilts and finally deliquesces, this action being probably hastened by bacteria, as these organisms are abundant in old specimens.

CONSIDERATIONS REGARDING THE TAXONOMIC POSITION OF THE GENUS.

From a consideration of the facts set out above, it is seen that until the appearance of the first cavity the development of the two species is somewhat similar to that of *Agaricus Rodmani*, as recorded by Atkinson (1915); but from this stage onwards the development has little in common with that of *Agaricus*, or in fact with that recorded of any member of the Hymenomycetes, but approaches closely that of certain genera of the Hymenogastrineae. In particular, the repeated appearance of fresh lacunae in the undifferentiated portions of the gleba, followed later by the appearance of these spaces in the tramal plates, is in close agreement with the development of the gleba in certain genera of this family. Further, the indehiscent nature of the peridium, the cellular structure of the gleba, the basidial characters and copious spore production are

typically gasteromycetous characters. In fact, were these plants devoid of columella and stipe, they would be placed in the Hymenogastrineae without hesitation. Taking these facts into consideration the writer believes that the genus must be retained in the Gasteromycetes.

On account of the structure of the gleba, the nature of the basidia and spores, and the presence of a definite stipe and columella, the genus forms a well-defined group. The presence of the stipe and columella, together with the similarity of the early developmental stages, would tend to link it with the Agaricaceae, whereas the nature of the gleba and peridium, together with the later developmental characters, link it with certain genera of the Hymenogastraceae. It therefore occupies an intermediate position, and as no genera are known connecting it with either family it should be retained in a distinct family. The Secotiaceae of Fischer (1900) will, however, have to be emended to include only those genera possessing a stipe, columella, cellular gleba, tetrasporous sterigmatic basidia, those with a capillitium being excluded. As the structure and development of the other genera which Fischer has included in the Secotiaceae are practically unknown, no opinion can be expressed concerning them.

From a consideration of the available literature it appears to the writer that the present unsatisfactory classification of the Gasteromycetes can be attributed to: (*a*) little or no consideration having been taken of developmental characters, (*b*) genera and species having been based almost solely on morphological (macroscopic) characters, and (*c*) the microscopic structure of the basidium, spores and other characters having been completely ignored. It is hoped to investigate the development of all the genera of New Zealand Gasteromycetes with the view that ultimately sufficient information will be collected to place the classification of this sub-class on a more satisfactory basis.

The writer wishes to acknowledge the assistance of Mr J. C. Neill of this laboratory for aid in collecting and for preparing the sections of the developmental stages of both species.

SUMMARY.

1. The development of two species, *Secotium erythrocephalum* Tul. and *S. novae-zelandiae* G. H. Cunn., is dealt with.

2. Differentiation of the stipe and columella precedes the formation of the first glebal cavity in *S. novae-zelandiae*, and follows its appearance in *S. erythrocephalum*.

3. Following the appearance of the first glebal cavity, the gleba of both species becomes further differentiated through the appearance of numerous lacunae in the primordium of the gleba surrounding the columella.

4. Spores make their appearance shortly after the formation of the first few cavities, when the plant is less than one-third the normal size.

5. A definite partial veil is present, but a universal veil is wanting.

6. Early developmental stages, until the appearance of the first glebal cavity, resemble those of *Agaricus*, later stages resemble certain genera of the Hymenogastraceae.

7. Spores and hyphae are binucleate.

8. The genus should be retained in the Gasteromycetes, preferably in a distinct family, the Secotiaceae (emended).

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EXPLANATION OF PLATES XI AND XII.

[The drawings have been made with the aid of a camera lucida.]

Fig. 1. Section of a tramal plate of *Secotium erythrocephalum* Tul. *Tr.* = trama; *sub.* = subhymenium; *hy.* = hymenium. × 1000.

Fig. 2. Basidia of *S. novae-zealandiae* G. H. Cunn. × 1000. Showing various stages of nuclear division and spore formation. Fifth basidium (from left) shows the original binucleate condition, the second basidium shows these nuclei before fusion, the fourth the fusion nucleus; the sixth basidium shows four nuclei prior to migration into the spores, the first basidium shows the spores, each with a single nucleus; the third basidium bears four binucleate spores.

Fig. 3. Clamp connections from hyphae of the partial veil. × 1000.

Fig. 4. Photograph of *S. erythrocephalum*. Natural size.

Fig. 5. Photograph of *S. novae-zelandiae*. Natural size.

S. novae-zelandiae.

Fig. 6. Undifferentiated primordium. × 30.

Fig. 7. First appearance of the radial cavity. × 30.

Fig 8. The radial cavity has enlarged and is becoming divided into smaller areas by downgrowths from the roof of the cavity. × 25

Fig. 9. Young plant, showing greatly elongated stipe, well-defined partial veil and cavity of the stipe. × 20.

Figs. 10–12. Progressive development of the peridium and gleba. × 10.

Fig. 13. Not quite median section through a mature plant (lamellar form). × 4. Note that the base of the peridium is still attached to the stipe by remnants of the partial veil. The stipe is cut at an angle, hence the cavity is not shown in the section. Perforations in the stipe are due to insect injuries.

S. erythrocephalum.

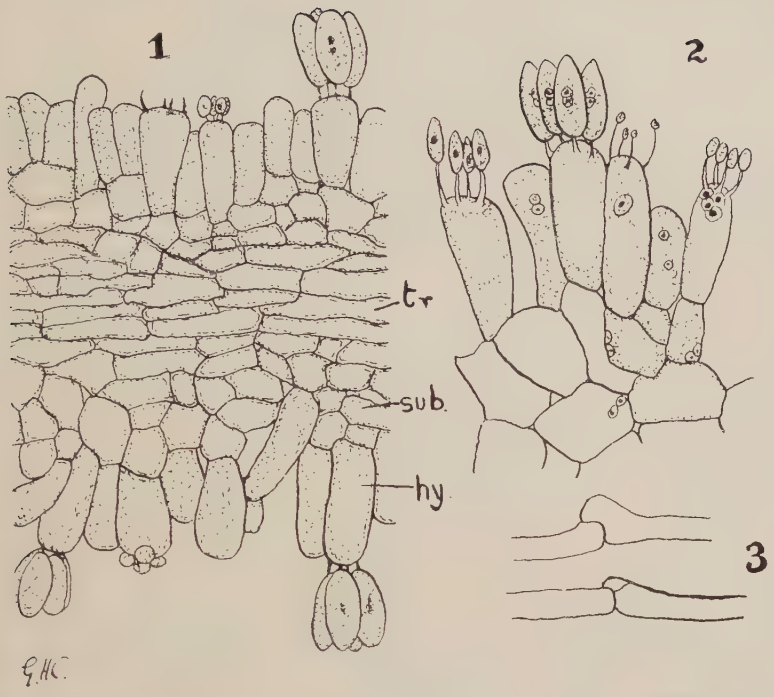
Fig. 14. Plant after first septa have been formed in the first glebal cavity. (The earlier stages are similar to the preceding, so are not shown.) × 30.

Fig. 15. Later stage in which numerous plates have appeared. Note the well-developed partial veil. × 25.

Fig. 16. Later stage showing further development of the gleba. × 15.

Fig. 17. Section showing the tremendous development of the gleba. × 8.

Fig. 18. Not quite median section through mature plant (small form). Note that the base of the peridium is attached to the stipe. The cavity of the stipe is not apparent, owing to the stipe being cut at an angle. Perforations in the stipe are due to insect injuries.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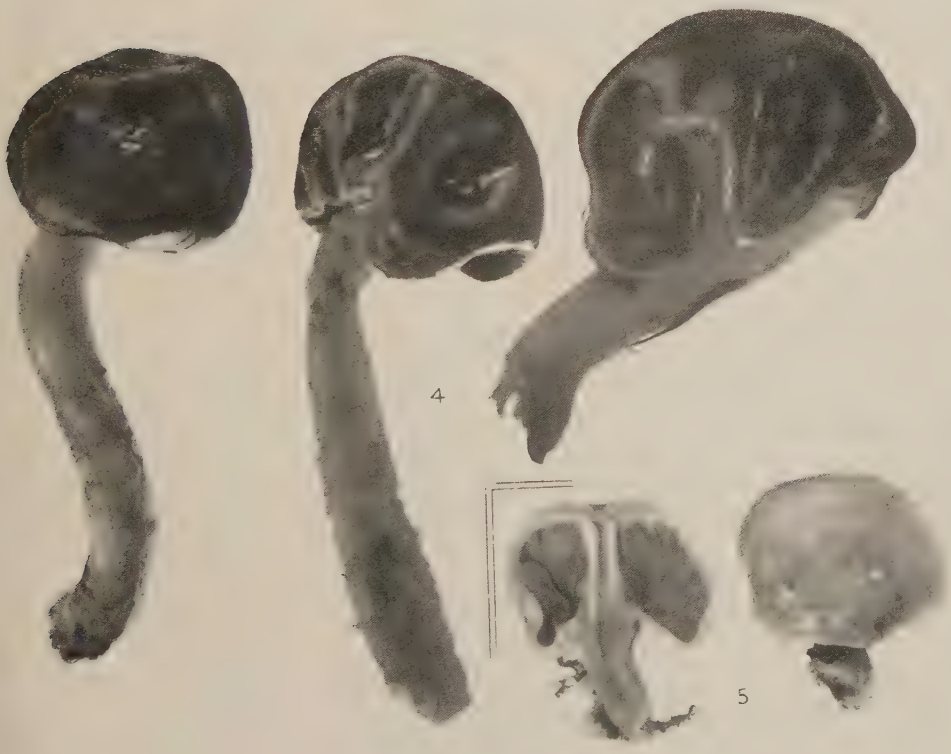
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POLYPORUS ADUSTUS (WILLD.) FR. AS A WOUND PARASITE OF APPLE TREES.

By F. T. Brooks.

Polyporus adustus is of common occurrence as a saprophyte on stumps of broad-leaved trees, but the only previous record of it as a tree parasite is that by Miss E. M. Prior, who in a paper entitled "Contributions to a knowledge of 'the snap-beech' disease" (*Journal of Economic Biology*, 1913, p. 249), considered it to be the cause of this disease of beech trees.

In recent years considerable damage has been caused to apple trees in the Wisbech fruit-growing district by the entry of a fungus through wounds which were made in the process of thinning out mature trees, large wounds being especially prone to attack. *Stereum purpureum* often enters such wounds, but this is by no means the only fungus which behaves as a wound parasite in apple trees. Silvering of the foliage is not associated with the fungus now under consideration. The progress of this fungus in the tissues is marked by the death of the bark as well as the disorganisation of the wood, and one of the marked symptoms of this kind of attack is the cracking of the bark. Sometimes the growth of the fungus is stayed and then a marked fissure develops between the healthy and dead bark. Valuable fruiting branches of apple trees are often attacked and killed in this manner, but I have not yet seen an entire tree killed by this fungus, probably because in the plantation where the disease is most prevalent special care is taken to excise the fungus at an early stage. Nevertheless the cropping capacity of trees thus attacked is greatly reduced. No variety of apple grown in this district appears to be immune to this trouble, but Mr W. G. Kent informs me that the varieties most seriously affected are Newton Wonder and Lord Derby.

Protection of the wounds with Stockholm tar and with gas tar has been found utterly ineffective to prevent the entry of the fungus. Work on silver-leaf disease has shown that Stockholm tar is practically worthless as a protection against *Stereum purpureum* (Brooks and Storey, "Silver-leaf Disease IV," *Journal of Pomology*, 1923), and recent unpublished investigations on the same disease indicate that gas tar is equally ineffective in this respect. Much better results have been obtained in preventing attack by *S. purpureum* by covering wounds with thick red-oxide paint or white-lead paint, and it is likely that these substances would also keep this other wound parasite at bay.

Considerable difficulty has been experienced in determining

the identity of the fungus which is causing this new trouble. Its fructifications have never been seen in the fruit plantations. Cultures of the fungus were repeatedly obtained from diseased tissues, but until lately these gave no signs of fruit-bodies. It seemed likely that a hymenomycetous fungus was involved and this has now been demonstrated by the formation of rudimentary polyporoid fructifications in the cultures. Recently, too, large branches of diseased apple trees have been kept under laboratory conditions suitable for the development of fructifications and as these have invariably given rise to typical fruit-bodies of *Polyporus adustus*, there is no doubt that this fungus is the cause of the injury. Further investigations are proceeding.

MUSHROOMS AND TOADSTOOLS.*

By J. Ramsbottom.

In common with the other Departments of the Natural History Museum, the Botany Department, in addition to its routine of scientific investigation, is constantly consulted by the general public. Questions of all kinds are received and it has sometimes happened that the seeker after truth has taken the wrong turning; the young gentleman who wished ever so much to see the sulphuric acid plant had presumably as peculiar ideas on chemistry as he had on botany.

At this time of the year almost every post brings along boxes in all states of dilapidation containing toadstools in all stages of freshness—both positive and negative. Apart from those which are sent by people curious in these matters, the usual type of accompanying letter is: "The enclosed were found growing in my garden. Would you kindly send me the name?" A post-script is almost invariable—and reads either, "I should like to know whether they are poisonous," or, probably what is more true, "whether they are edible." It would be interesting to learn the percentage of these enquirers sufficiently trustful of the considered opinion of a mycologist to put the specimens to the test. In these matters we of this country have little faith.

Although fungi have probably been eaten since prehistoric times and classical literature has constant references to both their edible and their poisonous qualities, for most of our countrymen there are only two edible fungi—the field mushroom and the horse mushroom. Dioscorides, a physician flourishing

* Broadcast from London Station (2LO), September 21st, 1923, as one of a series of talks by members of the staff of the British Museum (Nat. Hist.).

almost 2000 years ago, divided fungi into those which were poisonous and those which were not—and it sometimes requires such a statement, somewhat embellished, to persuade rural cooks to allow one to sample one's finds. On the other hand, it is common knowledge that on the Continent many kinds of toadstools are eaten; charts giving the characters of good and bad species are to be seen in the villages of France and in the schoolrooms of Central Europe; and most of us have seen the gentlemen from Soho on their Sunday strolls through Epping Forest in search of material for their "Cèpes à la bordelaise" and "Poulard truffé". Moreover, Covent Garden, though displaying now only the field mushroom, in former days was not above harbouring Blewits, St George's Mushroom and the Parasol Mushroom, though never being anything like so catholic in its taste as are the continental markets. It might therefore not be a matter of surprise to learn that there are at least fifty kinds of toadstools of more or less common occurrence in this country which are wholesome, many of them being much more delicate in flavour than the common mushroom either wild or cultivated. In addition there are many more which are edible and many which do not attract normal people because of their small size, their appearance or their toughness. On the other hand, though the vast majority of toadstools are harmless, there are a certain small number which are poisonous.

Fungus poisoning may be grouped under various heads. Some people cannot eat fungi at all without discomfort, just as certain people must avoid strawberries, butter or honey. Again, simple indigestion may be caused by dietetic indiscretions; a heavy meal of mushrooms unaccompanied by other food, on returning from a long tramp, will probably cause regrets, as mushrooms are not very digestible. A third source of trouble is caused by eating specimens that are somewhat *passé*. Mushrooms should be eaten fresh—or left alone. Changes in composition occur in them with age just as in all other organic material. There is no more reason for purchasing putrid mushrooms than there is for acquiring mouldy meat or decaying fruit—and they are just as likely to cause inconvenience. In addition to these troubles for which fungi cannot be held directly responsible there is definite specific poisoning. This ranges from slight disorder to painful death.

Now, is there any way by which we can tell a poisonous species from an edible one? Does it peel? does its flesh change colour on breaking? does it turn a silver coin black? do animals eat it? does it grow in a wood? does it grow on highly-manured ground? does it exude milk? and many more. Every nation has similar tests and Pliny, Dioscorides and other classical authors had them.

Though hoary with antiquity all and every one is utterly worthless. There are two methods I know, and two only, for distinguishing between wholesome and unwholesome species. The first, which is probably the surer way—at least it is widest in application—is by sampling a given specimen. If nothing is heard further from the fungus it is edible: you can then decide which class it should enter—good to eat, or fit to be eaten only on the Continent. I ought to add that experiments with domestic animals are not always to be relied on so that results obtained by trying it on the dog are not absolutely conclusive. The second of the two methods is the safer, and that is to be able to identify the fungus just as one does a cow, a cabbage or any other object.

One can then find out its record and proceed accordingly. A famous Chancery judge used the opposite method and from Scotland used to write to me: "I have sampled the enclosed and find them delicious and should therefore like to know their names." Like the old lady who died through drinking tea, he did not long survive his ninety-fifth year.

Identification of the best of the edible species is a comparatively easy matter if sufficient trouble be taken to learn their characters. Anyone who can be certain of a field mushroom should have no trouble whatever in distinguishing many of the edible kinds. In the Botanical Exhibition Gallery at the Natural History Museum we have a complete series of coloured drawings of the British species of toadstools, as well as other smaller series showing a few of the more characteristic edible and poisonous forms, and of the field and cultivated mushrooms and species likely to be mistaken for them. If these (or other coloured drawings) be consulted and descriptions studied so that the points which have been found of value in distinguishing between them are thoroughly understood, there should be no more trouble in learning say fifty of these than there is in learning the cards of a pack. Though the popular idea that all toadstools are poisonous is ludicrous, indiscriminate eating of them is a pastime that should not be indulged in. Although men of experience in these matters may safely experiment, it would be the height of folly for others to enter lightheartedly on the adventure. The most poisonous fungus known is quite common all over the country and occurs in such places as Kew Gardens, Wimbledon Common and Richmond Park. This is *Amanita phalloides*. It has no popular name; but very few of the 2000 or so larger fungi have. Of more than 500 deaths from fungus poisoning recorded during the last half-century, 90 per cent. have been brought about by this fungus. In the button stage there is some very slight resemblance to the field mush-

room, but it hardly seems credible that anyone could mistake one for the other. One striking difference is that the gills always remain white and do not start pinkish and pass to dark purplish-brown. Statistics show that over half of those poisoned by this fungus die—others recover after one to three weeks of acute suffering. One disturbing fact is that the pains do not begin until at least eight hours after the meal. Intense abdominal pains, violent diarrhoea and vomiting ensue. The lurid details of the sufferings need not be entered into: in the majority of cases death occurs on the third or fourth day. To show the uselessness of the ordinary rules for spotting poisonous toadstools, *A. phalloides* peels beautifully, does not blacken a silver spoon, has a pleasant taste, and slugs grow fat on it. But doubtless sufficient has been said to suggest that trying just a little for lunch, and then if there are no ill effects having a good portion at dinner, is not so safe a way as taking much less trouble and learning the external characters once and for all.

There are one or two close relatives of *A. phalloides* which should similarly be avoided. The best known of these is the Fly Agaric, *A. muscaria,* which has a bright scarlet cap covered with white warts and appears in autumn usually in the neighbourhood of birch trees. This receives its common name from the fact that it was formerly used, broken up in milk, for killing flies. It is not so poisonous as *A. phalloides*. Moreover, its bitter and unpleasant taste and its very bright colour deter any but infants from eating it. The trouble starts almost immediately and in spite of popular tradition apparently does not cause the death of healthy people. The symptoms are mainly those of excessive intoxication and this accounts for the fact that certain Siberian tribes make use of this fungus in their religious ceremonies and orgies.

It is obvious that the few toadstools with bad reputations are pretty well known and fathers of families would be wise to leave alone all such. There seems no reason, however, to go to the length advocated by the seventeenth century botanist and poet, Sir John Salusbury:

> Let my advice perswade thy mynde
> not to truste any of that kynde
> such as be takenn for the beaste
> doe proue as poisnusse as the reste.

NOTE.

RHIZOMORPHS IN DRAIN.

(With Photograph, Plate XIII.)

In the autumn of 1923 it was reported that a drain-pipe in front of the Masonic Temple in Crown Street, Aberdeen, was blocked by material, which appeared to be plant roots. The pipe was six inches in diameter, and thirteen feet below ground. A mass of material about seven feet long was taken from the pipe, and on examination it was found to be the rhizomorphs of a fungus. The largest of these rhizomorphs reached a diameter of 1 centimetre.

It is unknown where the fungus came from. A piece of decayed wood was found near the drain, but it was destroyed before it could be examined.

The drain was laid down twenty-five years ago.

E. C. BARNETT.

REVIEW.

Researches on Fungi, Volumes II and III, by A. H. Reginald Buller. Longmans, Green & Co., pp. xii+492, 1922 and pp. xii+611, 1924. 25*s.* and 30*s.*

All who read volume I of Professor Buller's account of his fascinating researches on spore-discharge in the higher fungi have been looking forward in recent years to the appearance of other volumes of this series. Volumes II and III are now published, and those who have been expecting a renewal of the intellectual treat provided by volume I will not be disappointed. The main theme throughout these books is the same, viz. the consideration of the fructifications of the higher fungi from the standpoint of their efficiency in the production and liberation of large numbers of spores. As the author remarks in the preface to volume II, "The morphological and physiological facts which have come to light in the course of my researches have taught me that the adaptation of structure to function in the higher fungi is just as remarkable as that found in the Phanerogamia."

In volume II the author discusses first in detail the mechanism of spore discharge from the basidium, and then, having indicated that this is essentially the same in all groups of the Hymenomycetes, proceeds to describe with great elaboration the organisation of the hymenium in the *Panaeolus* sub-type of fructification in the Agaricineae, characterised by mottling of the gills and the presence of monomorphic basidia, and exemplified by *Panaeolus campanulatus*, *Psalliota campestris*, and other common

fungi. The way in which Professor Buller elucidates the extreme efficiency of the gills of these fungi in spore-production is a model investigation in physiological anatomy.

Volume III opens with a similarly clear interpretation of the organisation of the hymenium in other sub-types of Agaric fructification distinguished for the first time by the author. The presence of polymorphic basidia in some of these sub-types is particularly interesting. This volume also contains a full description of four of the six sub-types of the *Coprinus* form of fructification, illustrated by *C. comatus*, *C. atramentarius*, *C. lagopus* and *C. micaceus* respectively; the author brings out clearly the special features of hymenial structure in each.

The latter part of volume III deals with spore-discharge in the Rust Fungi. The author confirms the observations of Klebahn and Zalewski respectively, that sporidia and aecidiospores are violently projected into the air, and points out for the first time that the essentially curved nature of the basidium in this group is an adaptation for unimpeded spore discharge. He contrasts ingeniously the loose arrangement of the multi-septate teleutospores of *Phragmidium* with the compact aggregation of the one-septate teleutospores of *Puccinia*.

Throughout these volumes a mass of interesting information about the higher fungi is given in addition to the description of hymenial organisation. For instance, the confusion that formerly existed in regard to the basidial and oidial fructifications of *Dacryomyces deliquescens* has been cleared up, and there are interesting chapters on Bioluminescence, parasitic Agarics, Slugs as mycophagists, and so on. It seems a pity, though, that the harmony of the main theme of the remarkable efficiency of the fruit-bodies of the higher fungi should be interrupted by the inclusion of these extraneous chapters, however interesting these are in themselves. Professor Buller has such an absorbing story to tell that interest should not be diverted.

The reviewer would offer one criticism: it is that these volumes are somewhat prolix. Volume III contains 611 pages and there seems no reason why its subject matter could not have been compressed into half the space. "Of making many books there is no end," but authors should have some compassion upon their readers, especially in these days when the output of scientific literature threatens to overwhelm the investigator.

Both the present volumes are profusely and splendidly illustrated. Everyone interested in mycology will look forward with eager expectation to volume IV of these researches, which the author has promised for the near future. These volumes will be a lasting memorial to the immense zeal and success with which Professor Buller has investigated the higher fungi.

F. T. B.

PROCEEDINGS, 1924.

PHYTOPATHOLOGICAL MEETING. *28th June.*

Visit to Reading.

DINNER TO OVERSEAS MYCOLOGISTS. *4th July.*

Criterion Restaurant, London.

AUTUMN FORAY AND ANNUAL MEETING, BETTWYS-Y-COED, N. WALES. *22nd—27th September.*

AUTUMN FORAY FOR LONDON STUDENTS. *11th October.*

Visit to Virginia Water.

AUTUMN FORAY WITH ESSEX FIELD CLUB. *18th October.*

Visit to Epping Forest.

AUTUMN FORAY WITH BRITISH ECOLOGICAL SOCIETY. *25th October.*

Visit to Burnham Beeches.

MEETING, UNIVERSITY COLLEGE, LONDON. *15th November.*

Dr W. ROBINSON. Some Conditions controlling Growth and Reproduction in *Sporodinia.*

Mr A. W. EXELL. Hymenial structure in three species of *Stereum.*

Mr W. J. DOWSON. A die-back of Rambler Roses caused by *Gnomonia Rubi* Rehm.

Miss C. A. PRATT. The staling of fungal cultures.

Mr J. RAMSBOTTOM. Fragmenta Mycologica (I).